Smithsonian Institution

MEMOIRS

OF THE

CARNEGIE MUSEUM.

VOL. VIII. No. 1.

A MONOGRAPH OF THE NAIADES* OF PENNSYLVANIA. PART III. SYSTEMATIC ACCOUNT OF THE GENERA AND SPECIES.[1]

BY ARNOLD E. ORTMANN, PH.D., SC.D.

(PLATES I–XXI.)

INTRODUCTORY.

In the first part of this monograph (Ortmann, 1911*b*),[2] certain anatomical features hitherto but little investigated were considered (*l. c.*, Pt. I, p. 282 ff.), and their bearing upon the rearrangement of the system of the Naiades was discussed in Part II (*l. c.*, pp. 322 ff.). At the end of Part II, a key for the genera was attempted (pp. 335–338). Since then additional material, chiefly representing

* In Parts I and II of this Monograph, which appeared in the Memoirs of the Carnegie Museum, Vol. IV, No. 6, I employed the term *Najades*, following the usage of certain well-known authors who have written upon this group. The spelling of this word given by Lamarck, who first employed it, was *Nayades*, and this would have priority according to a strict application of the laws governing nomenclature, were it not for the fact that the Lamarckian term plainly is an error in transcription from the original Greek, which is Ναϊάδες. I, believe that when a Greek word is used it ought to be transcribed as nearly as possible in conformity with philological usage, and therefore have reverted to the form *Naiades*, which is not only good Greek, but sanctioned by the usage of a multitude of other authors. The chief end of the "law of priority" is not to preserve and perpetuate mistakes in spelling, even when made by men as eminent as Lamarck.

[1] This paper is in continuation of the papers published in the Memoirs of the Carnegie Museum, Vol. IV, No. 6, 1911.

[2] The references given in the text refer to the bibliography at the end of this paper.

such forms as are not found in Pennsylvania, has been secured and studied. This made necessary a number of changes, which chiefly affect the division into genera, and which have been published (Ortmann, 1912). The system proposed in this latter paper will be used in the following pages with such corrections as have become inevitable in the course of still further studies.

With regard to the systematic literature, I have refrained from giving a full list of references and synonyms under each species, since the citations given by Simpson (1914) are as complete as could be desired. The quotation of the earlier reports from Pennsylvania was deemed desirable, in order to get an idea of the advance made in recent years in our knowledge of the subject.

Family **MARGARITANIDÆ** Ortmann (1911).

Ortmann, 1911*a*, p. 129; 1911*b*, p. 334; 1912, p. 223.

Genus Margaritana Schumacher (1817).

Ortmann, 1912, p. 230; Simpson, 1914, p. 511.

Type *Mya margaritifera* Linnæus.

1. **Margaritana margaritifera** (Linnæus) (1758).

Margaritana margaritifera (Linnæus) Simpson, 1914, p. 513.

Plate I, fig. 1.

Records from Pennsylvania:

Lea, Obs. II, 1838, p. 56, and VII, 1860, p. 225. As to the correctness of these records, see below.
Hartman & Michener, 1874, p. 91. See also below.
Conner, 1904, p. 91 (Still Creek, Quakake).
Ortmann, 1909*b*, p. 208.

Characters of shell: Shell large and heavy, cylindric-ovate, elongate, often arcuate when old. Anterior end rounded, posterior produced. Beaks very little elevated. Epidermis blackish or blackish brown. Nacre whitish, pinkish, or somewhat purplish, posteriorly iridescent. Pseudocardinal teeth present, laterals obsolete, generally entirely wanting. Inside of the mantle-line a number of small muscle-scars.

Size: My largest specimen (from Rene Mont) measures: L. 152 mm.; H. 67 mm.; greatest D. 49 mm. This is larger than any of the previous records. The maximum length given by Carl (1910, p. 65) for the form found in the Odenwald, Germany, is 136 mm. Israël (1910, p. 177) gives 140 mm. for the form from the Elster-drainage in Germany.

Soft parts and *glochidia* (See Ortmann, 1912, p. 230, fig. 1; and 1913*b*, p. 89). In the American form, the glochidia have not yet been observed. The fine teeth on the lower margin are present only in fully mature glochidia.

The *breeding season* in Pennsylvania occurs in the period from June to August (Conner, 1909, p. 112); in Europe it occurs from the middle of July to August (Harms, 1907, p. 818; Carl, 1910, p. 16).

Remarks: There is no possibility of mistaking this species, for it is sharply characterized by size (being the largest shell of the Atlantic-drainage), shape, color, hinge, and by its peculiar station. Compared with the same species from other localities, the Pennsylvanian specimens are remarkable for their size, being the largest ever recorded. I cannot see any differences between them and specimens from New England and Newfoundland. European shells likewise perfectly agree with them. Specimens from the Pacific slope are all considerably smaller and comparatively thinner, and the color of the nacre inclines more toward purplish tints. There are also slight differences in the hinge. This western form has been distinguished as a variety (*falcata* Gould).

Localities represented in the Carnegie Museum: [3]

Locust Creek, Tamaqua; Cold Run, Hecla; Indian Run, Rene Mont; all in Schuylkill Co., Pennsylvania.

Westfield, Hampden Co. (Hartman collection); Amherst, Hampshire Co., Massachusetts (Holland collection).

Amy Brook, Henniker, Merrimack Co., New Hampshire (G. H. Clapp).

Cape Elizabeth, Cumberland Co. (G. H. Woods); Aroostook River, Caribou, and Little Madawaska River, New Sweden, Aroostook Co., Maine (O. O. Nylander).

South West River, Belvoir Bay (Hare Bay), Newfoundland (G. H. Clapp).

From Europe (all received from W. Israël):

Perl Bach, Postfelden near Falkenstein, and Perlbach, Rehau above Hof, Bavaria; Goernitzbach, Oelsnitz, Saxony; Aumabach, Rohna, Saxe-Weimar; Steinach, Sonneberg, Saxe-Weimar; Ulfenbach, Affolterbach, Hesse, Germany.

From the Pacific slope (var. *falcata* Gould):

Long Valley, Lake Co., California (Hartman collection); Chehalis River, Porter, Chehalis Co. (H. Hannibal); Seattle (P. B. Randolph), and Ravenna Park, Seattle, King Co., Washington (H. Hannibal).

Distribution and Ecology in Pennsylvania (See fig. 1): This species has been recorded by Lea from Crum Creek, Delaware Co., and by Hartman & Michener from White Clay Creek, Chester Co. Lea also says that it goes southward only as far as middle Pennsylvania. I have expressed (1909*b*) my doubts as to the correctness of these two localities, and must maintain them most emphatically. In White Clay Creek I have collected myself, and found only the common fauna of the Atlantic streams, and *Margaritana* is not found where this is present, according to my experience.

[3] When not otherwise indicated, the specimens have been collected by myself.

The first to report an exact locality for this species in Pennsylvania was Conner (1904) Still Creek, at Quakake, Schuylkill Co. This creek is not named on the sheets of the U. S. Topographic Atlas, but it is, as I have ascertained, a tributary of the uppermost Little Schuylkill, and the place Quakake is no doubt the same as Quakake Junction, not far from Tamaqua. In the same general region, near Tamaqua, this species once used to be abundant in the headwaters of the Little Schuylkill, and its metropolis was in Locust Creek (See fig. 1) but the

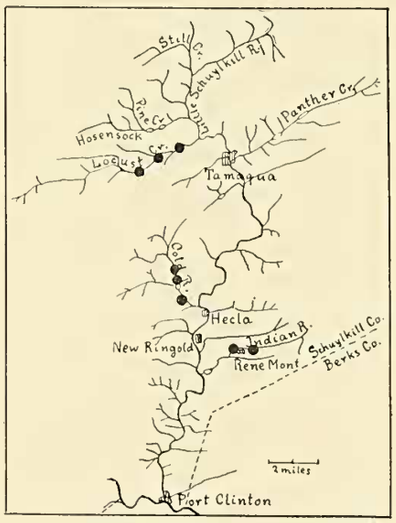


Fig. 1.

Glacial Preserve of *Margaritana margaritifera* in Pennsylvania.

recklessness of the pearl-hunters has nearly exterminated it. At the present time living specimens are rare in Locust Creek. The natives also report that it used to be found in Pine and Hosensock Creeks.

This species also occurs to the South of Tamaqua, in tributaries of the Little Schuylkill, in Cold Run, above Hecla, and in Indian Run, at Rene Mont. The latter locality marks the southernmost extension of the range of the species. Other creeks in this region also may have formerly contained this shell, but, as for instance in the case of Panther Creek, it must have been destroyed long ago by the pollution from the coal-mines.

The headwaters of the Little Schuylkill in Schuylkill County appear to be the only region in Pennsylvania where this species is found. It has never been reported from any other part of the state (except the spurious records mentioned above), and the efforts of myself, of Conner, and of Pilsbry to locate it elsewhere have only proved its absence. The writer devoted much time to hunting for it, or to securing information about its presence, in northern Schuylkill County, in

the upper Lehigh-drainage, in the Pocono Mountains, and in the region of the North Branch of the Susquehanna, but without success.

In the upper Little Schuylkill-drainage this species lives in mountain streams with cold water (trout-streams) at an elevation of 800 feet and more above sea-level. The sources of these streams are at about 2000 feet, and the greatest number of shells is found at about 1000 to 1200 feet. These streams are rough and full of little falls and rapids. The shell prefers eddies and pools which are rather deep, with a steady and lively current, and with gravelly and sandy bottoms. Sometimes these shells are found in sandy (but not muddy) bottoms of mill-ponds in quiet water, but they probably have been washed down into these. Cold water with lively currents seems to be essential, and also shade, for I chiefly found specimens in places where the banks of the streams were wooded, and not where they ran through open fields. The characteristic shrub in these woods is *Rhododendron maximum*, and besides *Alnus*, *Carpinus*, and often *Tsuga*.

In Europe it has been observed that *Margaritana* is missing in streams which run over limestone rocks, and that it is very impatient of water which holds lime (Haas, 1910, p. 109). The same is true in this country. All the streams in Schuylkill County in which it lives run over sandstones and shales. Indian Run is entirely in the Devonian Clinton Shales, while Cold Run and the more northern streams are in the Lower Carboniferous Mauch Chunk Shales, the boulders in the water-courses being formed by sandstones and conglomerates of the overlying Pottsville beds.[4]

The headwaters of the Little Schuylkill form a perfectly isolated station for this species, about one hundred miles away from the nearest locality, which is to the North, in Rockland County, in southern New York. The Pennsylvanian area of this species is not only the most southern extension of its range in eastern North America, but it also has the peculiarity of being the only one to the South of the Terminal Moraine. Thus it may be regarded as a part of the Glacial Preserve (*refugium*) of this species (See Ortmann, 1913*a*, pp. 377 ff.). *Margaritana margaritifera* in Pennsylvania is a fine example of a Glacial Relic.[5]

[4] In this connection I should mention that O. O. Nylander, who sent me specimens from the Aroostook River, Maine, states positively that the formation is Aroostook Limestone (Silurian. *Cf.* Williams, H. S., & Gregory, H. E., in *Bull. U. S. Geol. Surv., 165*, 1900, pp. 44 and 141). This matter, however, should be investigated more carefully.

[5] Subfossil shells of *Margaritana margaritifera* have been found in Hartman's Cave, near Stroudsburg, Monroe Co., Pa., associated with shells of *Elliptio violaceus* (*Unio complanatus*), bones of living and extinct vertebrates, and with human implements of stone, bone, and horn (See Leidy, 1889). I have seen, in the Philadelphia Academy of Natural Sciences, a left valve taken from Hartman's Cave, which undoubtedly is this species. This locality is *within* the glaciated area, and thus these remains are surely

General Distribution: This species is found, outside of North America, in northern and middle Europe, northern Asia, and Japan (Simpson, 1900, p. 677).[6] With regard to this, we do not need to go into detail here. Its North American distribution recently has been discussed by Walker (1910*a*, p. 140, pl. 2), and a careful list of localities has been given, to which we should add, however, a few new localities represented in the Carnegie Museum (see above), and further Buckfield, Oxford Co., Maine (Allen, J. A., in *Nautilus*, XXV, 1912, p. 120) (See also Nylander, 1914).

I do not think that *Margaritana margaritifera* is of North American origin, as represented by Scharff (1912, p. 51), but I believe that it reached eastern North America by the North Atlantic land-bridge, coming from Europe (See Scharff, *ibid.*). I also hold the opinion of Scharff that there were other places of survival during the Glacial time, either within the drift area, or close to its eastern edge, on the former eastward extension of the continent.

Family **UNIONIDÆ** (D'Orbigny) Ortmann (1911).

Ortmann, 1911*a*, p. 129; 1911*b*, p. 335; 1912, p. 223.

Subfamily UNIONINÆ (Swainson) Ortmann (1910).[7]

Ortmann, 1910, p. 116; 1911*a*, p. 129; 1911*b*, p. 335; 1912, p. 224.

Key to the Genera.

a_1. All four gills serving as marsupia. Mantle connection between anal and supra-anal openings present, short, and deciduous.

b_1. Placentæ subcylindrical, rather persistent, often red. Shell smooth, without sculpture upon the disk. Beak-sculpture simple, concentric, and poorly developed..... *Fusconaia.*

b_2. Placentæ lanceolate and compressed, not very persistent, whitish, or yellowish, but not red.

postglacial. This would indicate, possibly, a very early step in the postglacial dispersal of this species, provided these shells are actually from the neighborhood of this cave, and have not been carried there by man from a long distance. At present, *Margaritana* is not found in this region. I have hunted for it in vain in Broadhead Creek at Henryville (above Stroudsburg), and have received the assurance from competent persons that nothing resembling this shell is found in the trout-streams within a radius of at least fifty miles from Henryville.

[6] It also has been reported from Iceland, but this has been questioned. The Carnegie Museum has received from W. Israël a specimen labeled "Reykjavik, Iceland." After correspondence with Israël and Stejneger (in Washington), and by Stejneger with parties in Copenhagen, there remains no doubt that this specimen is to be traced back to a dealer in Copenhagen, who tried to impose upon a number of conchologists. He even claimed that the specimens in question were collected by Mrs. Israël in 1863, before she was born!

[7] This subfamily cannot be credited to v. Ihering (1901, p. 53) since he used the name in an entirely different sense.

Shell with sculpture upon the disk (ridges or tubercles). Beak-sculpture concentric, double-looped or zig-zag.

c_1. Chief sculpture upon disk consisting of a few oblique, strong undulations. Beak-sculpture concentric.....*Amblema.*

c_2. Chief sculpture on disk consisting of tubercles and warts. Beak-sculpture concentric, double-looped, or zig-zag.....*Quadrula.*

a_2. Only the two outer gills serving as marsupia.

b_1. Shell more or less tubercular upon the disk.

c_1. Beak-sculpture well-developed, consisting of numerous wavy ridges. Nacre dark purplish. Soft parts whitish. No supra-anal.....*Rotundaria.*

c_2. Beak-sculpture rudimentary, consisting of a few obscure, concentric bars. Nacre light-colored. Soft parts generally pale orange. Supra-anal present.....*Plethobasus.*

b_2. Shell smooth upon disk, without tubercles.

c_1. Shell rather thick and solid, short and high, sometimes drawn out posteriorly, and then distinctly cuneiform and oblique.....*Pleurobema.*

c_2. Shell generally not very thick, often rather thin, not short and high, but more or less elongated, and not oblique.....*Elliptio.*

Genus Fusconaia Simpson (1900).

Ortmann, 1912, p. 240; Simpson, 1914, p. 865 (as section of *Quadrula*).

Type *Unio trigonus* Lea (= *F. flava trigona*).

Key to the Species and Varieties.

a_1. Shell without a distinct posterior ridge, disk rather uniformly convex. Color brownish, or blackish brown.

b_1. Diameter of shell fifty percent of length, or more.....*F. subrotunda.*

b_2. Diameter of shell less than fifty percent of length.....*F. subrotunda kirtlandiana.*

a_2. Shell with a distinct posterior ridge, disk flattened, or even slightly concave in front of the ridge. Color lighter, more reddish or yellowish brown.

b_1. Shell attaining a good size. Growth-lines irregular.

c_1. Diameter of shell less than fifty-five percent of length.....*F. flava.*

c_2. Diameter of shell fifty-five percent of length or more.....*F. flava trigona.*

b_2. Shell much smaller. Diameter very variable, but mostly considerable. Growth-lines very distinct and regular.....*F. flava parvula.*

Fusconaia subrotunda (Lea) (1831).[8]

Quadrula subrotunda (Lea) Simpson, 1914, p. 892.

Plate I, fig. 2.

Records from Pennsylvania:

Harn, 1891, p. 137 (western Pennsylvania).

Clapp, 1895, p. 116 (*U. pilaris* from Allegheny County is undoubtedly this).

[8] This should not be called *F. sintoxia* (Rafinesque), although Vanatta (1915, p. 558) identifies Rafinesque's species with it. According to the measurements given by Vanatta, the diameter of Rafinesque's *sintoxia* is forty-three percent of the length; and thus it could only fall under *kirtlandiana*. But since the nacre is described as rose-colored, this does not seem likely since *subrotunda* and *kirtlandiana* have not rose-colored nacre.

Rhoads, 1899, p. 136, has recorded specimens of this species under *U. obliquus* from Coraopolis, Allegheny Co., and Beaver, Beaver Co.

Ortmann, 1909*b*, p. 200.

Characters of Shell: Shell large and heavy, swollen, the diameter amounting to fifty percent of the length or more, subcircular or ovate; when old, often oblique and drawn-out at the lower posterior end. No posterior ridge. Beaks moderately prominent. Beak-sculpture not distinctly observed, but probably weakly developed and concentric. Epidermis in young specimens light brown, almost yellow, with more or less distinct dark rays, which often appear as bundles of fine lines, and frequently break up into squarish spots, and with dark concentric growth-lines. In older specimens the epidermis turns darker, brown to blackish, and becomes nearly uniform without any rays.

Hinge-teeth heavy, pseudocardinals divergent in the young, becoming very heavy, and subparallel to the laterals, in old shells. Interdentum variable, but generally very wide, and beak-cavity very deep and compressed. Nacre always whitish.

	L.	H.	D.	Pr.ct.
Size: Industry, Cat. No. 61.3938*a*	107 mm.	81 mm.	53 mm.	.50

This is the largest specimen at hand. It fairly represents the average in outline, but the diameter has been unduly lowered by the production of the posterior end.

Soft parts and *Glochidia* (See Ortmann, 1912, p. 244).

Breeding season: Tachytictic form, breeding in June and July (Ortmann, 1909*a*, p. 101). Gravid females have been found on the following dates: June 22, 1909; June 24, 1909; July 3, 1908; July 11, 1911; July 5, 1909; July 13, 1908. Glochidia as well as eggs were found on July 5 and 13; on the other dates, eggs only.[9] The discharge of placentæ was observed in a few cases as early as June 24 (Ortmann, 1911*b*, p. 306), but this was in captivity, and was certainly premature.

Remarks: This is one of our heaviest and largest shells. Its external characters are rather indifferent, and it resembles several other species, with which it is easily confounded. In general the subcircular or oval outline, with rather evenly curved margins, and the deep, compressed beak-cavities characterize it. *Pleurobema obliquum catillus* comes very near to it, however, but this form is mostly more triangular, with the lower margin more nearly approaching a straight line, and with a more distinct lower posterior angle. It has only a rather shallow, and not a compressed, beak-cavity. Of course the characters of the

[9] Of the form from Elk River, West Virginia (var. *leucogona* Ortmann, 1913*b*, p. 89) I found gravid females as early as May 25, 1911, and as late as July 10, 1911.

soft parts are entirely different, and, when females are at hand, there is no mistake possible. The soft parts of *F. subrotunda* are often of the orange type, of *Pleurobema obliquum* never. Specimens with red nacre are always *obliquum*-forms, and never *subrotunda*.

There is no difference whatever between the sexes in the shell of this species. The differences between it and var. *kirtlandiana* will be discussed under the latter.

Much confusion prevails as to this species, and it has often been misidentified, probably because originally only the young was described, and no good figures of the old shell were published. The synonymy given by Simpson seems to be correct, but I think that the following reference should be added: *Unio varicosus* Lea (Obs. I, 1834, pl. 11, fig. 20, Ohio River). Lea compares this with *Plethobasus cyphyus* (= *œsopus*), and Simpson (1900, p. 765) identifies it with *Plethobasus cicatricosus* (Say). Lea's figure would stand very well for an old *Fusconaia subrotunda*, except for its color, which is too light, but I have several old specimens with a rather light (brown) epidermis, although not as light as in this figure. The color of Lea's *varicosus* is all that agrees with *Pleurobema cicatricosus*. According to specimens of the latter in the Carnegie Museum, and the figures of Reeve (1864, Pl. 8, fig. 31, and Pl. 13, fig. 50), the character of the concentric ridges of the shell is entirely different from that in Lea's figure. Furthermore the shape of the latter is not at all the characteristic shape of *cicatricosus*. The specific name *varicosus* would have priority (1829) over *subrotundus*, but cannot be used, since it is pre-occupied by *U. varicosus* Lamarck, 1819, now *Alasmidonta varicosa*.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Cooks Ferry, Shippingport, Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Mahoning River, Mahoningtown, Lawrence Co.

Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, Armstrong Co.

Monongahela River, Westmoreland Co. (G. A. Ehrmann), and Charleroi, Washington Co. (G. A. Ehrmann).

Cheat River, Cheat Haven, Fayette Co.

Other localities, represented in the Carnegie Museum.

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Tuscarawas River, Ohio (Holland collection).

Levisa Fork of Big Sandy River, Prestonsburg, Floyd Co., Kentucky.[10]

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).[11]

[10] Only one specimen found by myself. It has the diameter of fifty percent, and thus belongs here, but stands close to the var. *kirtlandiana*.

[11] These specimens do not differ from the general run of the form from the Ohio. In the upper

Distribution and Ecology in Pennsylvania (See fig. 2): This species belongs in Pennsylvania to the larger rivers, the Ohio, Allegheny, and Monongahela, to the Beaver as far as the lower Mahoning, and to the lower Cheat. It has never been found in any other tributary of the upper Ohio system. It prefers heavy shingle and gravel, in a strong current, and is especially adapted to this habitat by its

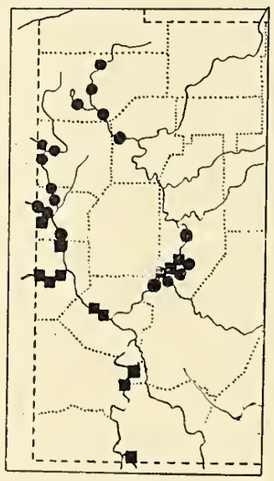


FIG. 2.

■ *Fusconaia subrotunda.*
● *Fusconaia subrotunda kirtlandiana.*

subglobular shape and heavy shell. In the Allegheny it occurs as high up as Kelly in Armstrong County; above this point, the river is largely polluted, so that the upper limit of its former distribution cannot be now ascertained, but it is positively missing in the upper Allegheny above Oil City, and is not represented by its variety *kirtlandiana*, while the latter takes its place in French Creek. In the upper parts of the Beaver-drainage it is also gradually replaced by *kirtlandiana*. Particulars about its range in the Monongahela are wanting, but it possibly reached a little beyond the West Virginia line. It is found in the lower Cheat, and has also been found in the Indian Garbage heap at Point Marion, opposite the mouth of the Cheat (See Ortmann, 1909*c*).

General Distribution:

Type locality; Ohio (Lea).

This species is positively known only from the Ohio-drainage, ranging from Pennsylvania westward to Illinois, and is generally restricted to the Ohio River

Tennessee region this species is represented by a dwarfed race, commonly called *U. pilaris* Lea. Also in Elk River, West Virginia, I have discovered a dwarfed race, which I have called var. *leucogona* (Ortmann, 1913*b*, p. 89), but I doubt now the propriety of distinguishing this by a name.

proper and some of its larger tributaries. Of the latter outside of Pennsylvania the Tuscarawas and Scioto Rivers contain it (Sterki, 1907*a*); it is in the Illinois River in Illinois (Baker, 1906). Call (1896*a*) does not mention this species from Indiana, but he unites it with *F. ebena* (Lea), and quotes this from the Ohio and Wabash. According to Blatchley & Daniels (1903) *subrotunda* is plentiful in the Wabash and Tippecanoe Rivers in Indiana. The form from Elk River in West Virginia (Big Kanawha-drainage) is slightly different (var. *leucogona*). Simpson (1900) cites the Cumberland and Tennessee river-systems, and Wilson & Clark (1914) confirm this for the Cumberland. Similar forms are, indeed, found in these rivers, but they generally go under different names (mostly *pilaris* Lea). Yet I have typical *subrotunda* from the Tennessee in northern Alabama. Its presence in the Big Sandy in Kentucky has been established.

All records from outside of this region are to be regarded for the present as doubtful, or positively wrong, as for instance, Grand River, Ontario, and Michigan. The records from Lake Erie given by Sterki (1907*a*, p. 391) and Ortmann (1909*b*, p. 203) do not refer to this species, but to *Pleurobema obliquum pauperculum*, and the same probably is true of Walker's record (1913, p. 22).

Toward the west and southwest, in the Mississippi-drainage, typical *subrotunda* is gradually replaced by the form or species *F. ebena* (Lea), which is, for instance, rather prevalent in the Ouachita River in Arkansas. The interrelation between *F. subrotunda* and *F. ebena* should be studied more closely especially in the lower Ohio and its tributaries.

Fusconaia subrotunda kirtlandiana (Lea) (1834).

Quadrula kirtlandiana (Lea) Simpson, 1914, p. 891.

Plate I, figs. 3, 4, 5.

Records from Pennsylvania:

Harn, 1891, p. 137 (western Pennsylvania).
Rhoads, 1899, p. 137 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 201.

Characters of variety: Shell with the outline of *F. subrotunda*, but much more compressed, and with less prominent beaks. The diameter is less than fifty percent of the length, falling as low as thirty-three percent. In consequence of the compression, the posterior part of the shell, behind the beaks, appears more elevated, almost wing-like. Color of epidermis generally brighter, chiefly so in young shells, which often possess a very light yellowish ground-color, with darker, well-marked growth-rests, and distinct black or dark green rays. In the old shell,

the color becomes more uniformly brown, and sometimes blackish. All other characters are like those of the main form.

	L.	H.	D.	Pr.ct.
Size: Clarksville, Cat. No. 61.3927	133 mm.	97 mm.	48 mm.	.36 (largest at hand).
Cochranton, Cat. No. 61.3923	128 "	111 "	51 "	.40

These specimens are superior in size to the largest *F. subrotunda.*

The *soft parts* and *glochidia* have been described and figured by Ortmann (1911*b*, Pl. 89, fig. 1, and 1912, p. 245).

Breeding season: The only gravid female ever found was obtained on August 2, 1908; it had glochidia. Among individuals collected June 25, 1907, and July 10 and 19, 1909, none were gravid, although a good many were obtained. This is rather astonishing. The one gravid specimen was the only one among a large number. Many have been collected later in the season, but no other gravid female has ever turned up.

Remarks: This form passes very gradually into *F. subrotunda,* and is positively recognized only by the compression of the shell. In order to distinguish these two forms I was compelled to introduce an artificial and arbitrary dividing line at the diameter of fifty percent of the length. Of course, this does not correspond to the natural conditions, but it is a wonderful help for the practical separation of the forms.

The other characters are also not reliable, although generally the color and the development of a posterior wing help in the identification.

The soft parts in *kirtlandiana* are more frequently of the whitish type, although the orange type is not rare.

In this form it is likewise impossible to distinguish males and females by the shell.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co. (W. F. Graham).

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Mahoning River, Mahoningtown, Coverts, Edinburg, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville and Clarksville, Mercer Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Allegheny River, Natrona, Allegheny Co.; Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Conneaut Outlet, Conneautlake, Crawford Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Cheat River, Cheat Haven, Fayette Co.

Other localities represented in the Carnegie Museum:

Mahoning River, Ohio (Hartman collection) (Topotype).
Tuscarawas River, Ohio (Holland collection).
West Fork River, Lynch Mines, Harrison Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

Distribution and Ecology in Pennsylvania (See fig. 2): The distribution of this form in Pennsylvania clearly indicates that it is the representative of *F. subrotunda* in the smaller rivers and creeks, but that it passes in the downstream direction into the latter, and is associated with it in the larger rivers. Its metropolis is in the Beaver system and French Creek. In these it is practically everywhere, and lives in coarser or finer gravel, even in sand, and in more or less rapidly flowing water. It avoids, however, the extreme headwaters, and is not found in the Shenango above Clarksville, and not in French Creek above Cambridge Springs. The records from some smaller tributaries (Pymatuning Creek and Conneaut Outlet) are founded upon single individuals.

In the larger rivers, the Allegheny, Monongahela, and Ohio, it is also present, but its place is gradually taken by the typical *F. subrotunda.* From Cooks Ferry in Beaver County down the Ohio to Portsmouth, Scioto County, Ohio, the typical form alone is present. Exceptionally large and posteriorly produced specimens may exhibit the dimensions of *kirtlandiana,* but such are very rare in this section of the river, and generally it is clearly evident that they were typical *subrotunda,* when young.

General Distribution. Type locality, Mahoning River, Ohio (Lea).

This variety appears to be restricted to the tributaries of the upper Ohio in West Virginia, Ohio, and Pennsylvania. The river which forms its type locality in Ohio also contains it in Pennsylvania, and it occurs also in the other branches of the same river-system (the Shenango and Beaver). I further have ascertained that it is found in French Creek, and the upper Monongahela, its range going down for some distance into the larger rivers. I also found it in the Little Kanawha in West Virginia.

Simpson (1900) quotes it from the " Ohio, Cumberland and Tennessee River systems, southwest to Arkansas, north to Wisconsin (?), east through southern Michigan." I think that this wide range is entirely erroneous. Looking over the literature we find it reported from Ohio (aside from the Mahoning River) from the Ohio itself and some of its tributaries, especially from the Tuscarawas River (Sterki, 1907*a*). Further it is mentioned from the Grand River in Michigan (Call, 1885, and Walker, 1892 and 1898), and from Waukesha, Waukesha Co.,

Wisconsin (Call, 1885). This latter locality is doubted by Simpson, and I believe that of all these localities only the Tuscarawas River is reliable.

Outside of the upper Ohio region positive and trustworthy records are absent. Thus, for instance, this shell is missing in the Cincinnati Catalogue of Harper (1896). Sterki's records from other parts of the state of Ohio are very vague. Call (1896*a*) does not mention it from anywhere in Indiana, and so forth. The Michigan record is founded upon Call's authority, and stands by the side of another one (Wisconsin), which is certainly in error.

Apparently this form has been frequently misunderstood, even by Simpson, and this is the more probable, since corresponding, but not entirely identical, forms are met with elsewhere. A flat form of *F. subrotunda* is found in Elk River, West Virginia. This I have distinguished as var. *leucogona* (Ortmann, 1913*b*, p. 89), but in the lower part of this river the connection with typical *subrotunda* recurs.

All this tends to show that *F. subrotunda* has the tendency in the headwaters of the Ohio to develop a flat form, called *kirtlandiana*, constituting an ecological race of the main species. I wish to call special attention to this; as we shall see further on that similar phenomena present themselves to view in the case of other species.

Fusconaia flava (Rafinesque) (1820).

Quadrula rubiginosa (Lea) Simpson, 1914, p. 872; *Quadrula flava* (Rafinesque) Vanatta, 1915, p. 557; *Fusconaia flava* (Rafinesque) Utterback, 1916, p. 26.

Plate II, fig. 3.

Records from Pennsylvania: [12]

Clapp, 1895, p. 116 (Allegheny Co.).[13]
Rhoads, 1899, p. 137 (Ohio River, Coraopolis, Allegheny Co.).[13]
Ortmann, 1909*b*, p. 199.

Characters of the shell: Shell of medium size, but rather heavy. Outline subtrapezoidal. Beaks not very prominent, and not inflated. Beak-sculpture consisting of three to five subconcentric bars, slightly waved, forming an angle upon the posterior ridge, and most distinct there. Often these bars are quite

[12] Marshall (1895, p. 90) quotes this species from the Allegheny in Warren Co., but I consider this an error. Just this instance (and a few others) induce me to question the accuracy of the locality of some of the species recorded from Warren Co. I have repeatedly collected in this region, but did not find any evidence for the existence of this form.

[13] The localities in Allegheny Co. are in the region, where the transition from *flava* into *trigona* takes place. Some of Rhoads' specimens should be called *flava*.

indistinct, even on well-preserved beaks. The fourth and fifth bars are generally marked only by nodular swellings upon the posterior ridge.

Shell rather compressed; diameter less than fifty-five percent of length. Sides flattened, or even with a shallow depression in front of the posterior slope. The latter separated from the sides of the shell by a distinct posterior ridge. Ventral margin from straight to broadly and gently emarginate.

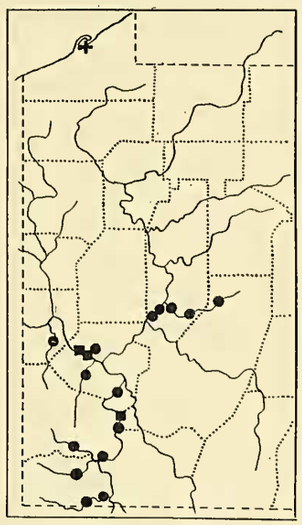


FIG. 3.
■ *Fusconaia flava trigona.*
● *Fusconaia flava.*
+ *Fusconaia flava parvula.*

Surface without sculpture. Epidermis rather light brown, or of a chestnut or russet hue, rarely showing some green, with fine, indistinct, greenish or brownish rays, and dark growth-rests. When older, the rays disappear, but the epidermis remains rather light, and only in very old shells turns dark brown or even blackish.

Hinge-teeth well-developed; pseudocardinals divergent, rather strong. Interdentum present, but not very broad. Beak-cavities not very deep. Nacre white, often suffused with salmon-pink.

	L.	H.	D.	Pr.ct.
Size: 1. New Sheffield, Cat. No. 61.3343	95 mm.	71 mm.	44 mm.	.46
2. Rosston, Cat. No. 61.2973	65 "	48 "	28 "	.43

Soft parts and Glochidia (See Ortmann, 1911*b*, Pl. 89, fig. 2, and 1912, p. 241, fig. 4).

On May 24, 1911, in the Little Kanawha River, at Burnsville, Braxton Co., West Virginia, I found among numerous gravid females with normal (red) color

of the placentæ a single one, in which they were pure white. This has remained the only case of this kind. (I have seen over one hundred gravid females.)

Breeding season: Gravid females have been observed on the following dates. May 6, 1910; May 9, 1913; May 17, 1910; May 22, 1912; May 24, 1911; May 27, 1908; June 30, 1908; July 3, 1908; July 8, 1907; August 3, 1909; August 10, 1909. In the month of May only eggs were found, at the other dates eggs and glochidia, or only the latter. The species is typically tachytictic, breeding from May to August.

Remarks: This is a rather characteristic shell, but it has been frequently confused with other species, chiefly with *Pleurobema obliquum coccineum* (Conrad). Nevertheless the peculiar, subtrapezoidal shape, the pale brown or reddish epidermis, the flat sides, and distinct posterior ridge, always serve to distinguish it. It is, however, quite variable, and, as we shall see below, three varieties may be distinguished in Pennsylvania, and there are others outside of this state, which have often been regarded as distinct species. In spite of this it has been positively ascertained that these varieties actually intergrade in our region.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Neville Island, Allegheny Co.

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson & Graf); Charleroi (G. A. Ehrmann) and Millvale, Washington Co. (J. A. Shafer).

Raccoon Creek, New Sheffield, Beaver Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson & Graf).

North Fork Tenmile Creek, Amity, Washington Co.; South Fork Tenmile Creek, Waynesburg, Greene Co.

Dunkard Creek, Wiley and Mount Morris, Greene Co.

Allegheny River, Godfrey, Johnetta, and Kelly, Armstrong Co.

Crooked Creek, Rosston and Southbend, Armstrong Co.; Creekside, Indiana Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Genesee River, Chili and Rochester, Monroe Co., New York (R. H. Santens).

Sandusky River, Fremont, Sandusky Co., and Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).

Miami-Erie Canal, Lucas Co., Ohio (C. Goodrich).

Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich); Fort Wayne, Allen Co., Indiana (C. Goodrich).

St. Mary's River, Rockford, Mercer Co., Ohio (C. Goodrich).

Beaver Creek, Williams Co., Ohio (C. Goodrich).

St. Joseph River, Indiana (B. Walker).

Raisin River, Grape P. O., Monroe Co., and Adrian, Lenawee Co., Michigan (C. Goodrich).

Clinton River, Utica, Macomb Co., Michigan (B. Walker).

Ohio-drainage:

Tusearawas River, Ohio (Holland collection).
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
Chillicothe, Ross Co., Ohio (Hartman collection).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Wabash River, New Corydon, Jay Co., Geneva, Adams Co., and Bluffton, Wells Co., Indiana (C. Goodrich).
Little Kanawha River, Burnsville Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Poeatalico River, Raymond City, Putnam Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Drainage of upper Mississippi and Red River of the North.

Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).

Western and Southwestern Range.

Meramee River, Meramee Highlands, St. Louis Co., Missouri (N. M. Grier).
Wakarusa River, Lawrence, Douglas Co., Kansas (R. L. Moodie donor).
Wea Creek and Bull Creek, Miami Co., Kansas (C. Goodrich donor) (Osage drainage).
Neosho River, Burlington, Coffey Co., Kansas (R. L. Moodie donor).
Terre Noir Creek, Mount Zion, Clark Co., Arkansas (H. E. Wheeler).
Big Deeciper Creek, Gum Springs, Clark Co., Arkansas (H. E. Wheeler).
Chikaskia River, Tonkawa, Kay Co., Oklahoma (F. B. Isely).
Illinois River, Talequah, Cherokee Co., Oklahoma (F. B. Isely).
Blue River, Durant, Bryan Co., Oklahoma (F. B. Isely).

Note: The specimens from Arkansas and Oklahoma are absolutely indistinguishable from the Pennsylvanian form in shape and anatomy, but have generally a more brilliant, shining, reddish epidermis.

Distribution and Ecology in Pennsylvania (See fig. 3): In our state *F. flava* is eminently characteristic of smaller streams, avoiding the larger rivers, although it has been found in the Allegheny, Monongahela, and Ohio. It is most abundant in the southwestern section of the state (Monongahela-drainage), and locally is rather plentiful, as for instance in Raccoon, Tenmile, and Dunkard Creeks. In the Allegheny River it is rather scarce, but is found in considerable numbers in Crooked Creek. Nevertheless elsewhere in the Allegheny-drainage it is absent, which is especially true of French Creek and the uppermost Allegheny, where there is a rich fauna still present, which has been well investigated. It is also absent in the whole Beaver-drainage.

It is hard to say what may have caused this peculiar condition. Yet attention should be called to the fact that the Beaver River and French Creek belong to the Glacial area, and that all creeks in Pennsylvania, in which this species is found, are entirely outside of this area. In the Kiskiminetas, Red Bank, and

Clarion Rivers the fauna is entirely destroyed, and the few survivals we have in the headwaters of the Kiskiminetas do not include this species.

F. flava prefers fine gravel and sand, and avoids rough bottom and rocks. Its favorite stations are on bars of fine, firmly packed gravel, just below riffles.

General Distribution: Type locality, Small tributaries of Kentucky, Salt River, and Green River (Rafinesque).

Outside of Pennsylvania this form has a wide range. It has been reported from western New York (see below) westward as far as Kansas and southeastern Nebraska. Northward it passes into Canada and the drainage of the Red River of the North (Winnipeg, compare also our specimens from North Dakota). In Michigan, it is all over the southern half of the lower peninsula (Walker's map, 1898, Pl. 1). It probably reached the lake-drainage by several ways, but not through Pennsylvania, since it is missing in the Beaver and upper Allegheny basins.

From the Ohio River southward its range becomes obscure. As I have discovered, it is present in the Little and Big Kanawha-drainages in West Virginia, and also in the Big Sandy and Licking Rivers in Kentucky. The type locality is in central Kentucky. Records from Tennessee are missing, except that given by Wilson & Clark (1914) Stones River, Tennessee, tributary to the Cumberland. The localities quoted from Mississippi, Alabama, and Texas are more than doubtful. But, as our material shows, forms representing the species are certainly found as far west as Arkansas and Oklahoma, and although certain authors might call, and have called, these by different names, I am unable to distinguish them from the northern form, except by their more shining epidermis. (See Wheeler, 1918, p. 123.)

It would be interesting to know whether outside of Pennsylvania the rule likewise holds good, that this form prefers smaller creeks. This is certainly the case, wherever I have collected it in West Virginia and Kentucky.[14] The localities in Arkansas, and partly also in Oklahoma, are small creeks, while in the larger rivers (Ouachita) *F. flava undata* and *trigona* are found. Call (1900, p. 506) says that *rubiginosus* (*flava*) is found in Indiana, in streams both large and small, while Wilson & Clark (1912*a*, pp. 42, 43) report *flava* from the headwaters of the Kankakee system in Indiana, while they cite *trigona* from the lower Kankakee and Iroquois Rivers in Illinois. In the uppermost Wabash and in the Maumee C. Goodrich collected only typical *flava*, and here undoubtedly is one of the places, where it

[14] However, in Elk River in West Virginia this is not perfectly clear. Here is found a form which may be called a dwarfed *F. flava trigona*. But this is in keeping with the general character of the Elk River fauna, which should be designated as a dwarfed big-river-fauna. It is not the place here to give details of these remarkable conditions.

crossed into the lake-drainage. There is no doubt that *flava* has often been confounded with *trigona* (or even *undata*), and that it actually intergrades through *trigona* into *undata*.

FUSCONAIA FLAVA TRIGONA (Lea) (1831).

Quadrula trigona (LEA) SIMPSON, 1900, p. 787; *Quadrula undata* (BARNES) (Ohio-form) WALKER, 1910*b*, p. 22; *Quadrula undata* (BARNES) SIMPSON, 1914, p. 880 (*pro parte*).

Plate II, fig. 1.

Records from Pennsylvania:

Stupakoff, 1894, p. 135 (Allegheny Co.).
Rhoads, 1899, p. 137 (Ohio River, Coraopolis, Allegheny Co.).[15]

Characters of variety: This is a *Fusconaia flava* which has a more swollen shell, chiefly anteriorly, with a diameter of fifty-five percent of the length or more. In consequence of this the sides of the shell are generally more concave, forming a gentle radial depression in front of the posterior ridge. In other respects there are hardly any differences from the normal form.

		L.	H.	D.	Pr.ct.
Size: 1.	Neville Island, Cat. No. 61.1837*b*	67 mm.	52 mm.	38 mm.	.57
2.	do. Cat. No. 61.1633*b*	50 "	41 "	31.5 "	.63
	According to Lea's figure	59 "	49 "	38 "	.64

The *soft parts* have never been observed in Pennsylvania. But specimens referable to this form have been found with the soft parts in Elk River, West Virginia, and gravid females were found there on July 8, 1911, with glochidia. The anatomy is absolutely identical with that of *F. flava*, as are also the *glochidia:* L. 0.15 mm., H. 0.16 mm. A form indistinguishable from this was collected by H. E. Wheeler in Saline River, Arkansas (July 13, 1911), and the anatomy and glochidia of this form were the same.

According to the above dates, the end of the *breeding season* of this form falls in July.

Remarks: In this case also I have been compelled to draw an artificial dividing line, at the diameter of fifty-five percent, between two forms, while in nature a gradual transition exists. This is justified by the same practical considerations as in the case of *Fusconaia subrotunda* and *kirtlandiana*. Walker specifically unites the present form with *undata* and he is undoubtedly right. Yet I think we should recognize *trigona* as a distinct *variety*, with less developed beaks; while *F. flava undata* has much elevated and often incurved beaks. The range of the two forms

[15] I have (1909*b*, p. 183 and 187) questioned the correctness of this record, since Rhoads' specimens are too young. But it should stand,

also seems to be somewhat different, *F. flava undata* (Barnes), belonging to the larger rivers of the central basin, being absent in Pennsylvania. In the middle West (Illinois) these two forms seem, however, to overlap, and in the Southwest also both seem to be present, and, according to what Walker says, intergrades are present. The real *F. flava undata* is, in consequence of the higher beaks, more subtrigonal (not subtrapezoidal) in outline, and in addition has the tendency in the epidermis to become greenish rather than brownish.

From the measurements given above we see that some of our specimens agree rather closely with Lea's figure of *U. trigonus*. Others reveal transitions in the direction of *F. flava*. Specimens from Charleroi have been determined by Simpson as intergrades between *trigona* and *rubiginosa* (= *flava*), and this is entirely correct. We have here (or rather had) in the Ohio below Pittsburgh, and in the Monongahela above, a region, where *flava* gradually passes into *trigona*. Further upstream, chiefly in the Monongahela system, only more or less typical *F. flava* are found. The only way to bring order out of the chaos is to draw an artificial line, as I have done.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Neville Island, Allegheny Co.

Monongahela River, Westmoreland Co. (G. A. Ehrmann); and Charleroi, Washington Co. (G. A. Ehrmann).

Other localities represented in the Carnegie Museum:

Elk River, Sutton and Gassaway, Braxton Co., and Shelton, Clay Co., West Virginia.[16]

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

(A form indistinguishable from this has been received from various localities in the Southwest; but they cannot be distinguished from *U. chuni* Lea.)

Marais des Cygnes River, Rich Hill, Bates Co., Missouri (W. I. Utterback).

Caehe River, Nemo, Craighead Co., and Sedgwiek, Lawrenee Co., Arkansas (H. E. Wheeler).[17]

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).[18]

Kiamichi River, Tuskahoma, Pushmataha Co., Oklahoma (F. B. Isely).

Sabine River, De Soto Parish, Louisiana (L. S. Frierson).

Distribution and Ecology in Pennsylvania (See fig. 3): *F. flava trigona* is found in Pennsylvania only in the Ohio and lower Monongahela Rivers, and reaches here

[16] Smaller than the Pennsylvanian form, but agreeing in all other respects. A few specimens from Gassaway would fall under typical *flava*, but the diameter remains above fifty percent.

[17] In part cotypes of *F. sclecta* Wheeler (Nautilus, XXVIII, 1914, p. 76, Pl. 4). I eannot separate them from this form.

[18] In some of these, the diameter falls below fifty-five perecnt, but remains above fifty percent.

the uppermost limit of its distribution in the Ohio system. It is remarkable that I have not found this form or any representative of it in the Ohio in Beaver County. Its absence in the lower Allegheny may be accounted for by the general destruction of the molluscan fauna in these waters. Moreover *F. flava trigona* probably is extinct in the state at the present time. The specimens collected by myself at Neville Island were all dead, and there are no more shells at this locality, nor at Rhoads' locality, Coraopolis. Ehrmann's collections in the Monongahela were made before 1898, and most of his shells were found dead.

General Distribution. Type locality: Ohio River, Cincinnati and Louisville (Lea).

The distribution of *F. flava trigona* is very unsatisfactorily known. Walker reports it from the Ohio, and it extends westward to the Mississippi at Davenport, Iowa, and to the Wisconsin River, Sauk Co., Wisconsin (Walker).

The Carnegie Museum possesses a number of specimens from the Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren), which in general correspond with *F. flava;* but one among them, which is considerably swollen, might very well be considered to belong to the variety *trigona*. These shells are rather large, with blackish epidermis. The other localities mentioned above, are rather isolated (in West Virginia, Indiana, Arkansas, Oklahoma, Louisiana), but they tend to show that under certain conditions, the form *flava undata* passes, in localities remote from each other, into a form with less elevated beaks, which answers to the description of *U. trigonus* of Lea. What these conditions are, remains to be seen. Possibly *trigona* is the form of medium-sized rivers with strong currents.

It is remarkable that I did not see a trace of this form on my collecting trips down the Ohio between Pittsburgh and Cincinnati. The shell should be expected in this region, but careful examination of the shell-heaps of the clam-diggers and my own collecting did not bring to light a single specimen. Probably this form selects particular stations in the river, but of what character these are, is as yet unknown. At Neville Island in Pennsylvania, I found the dead shells in and above riffles in a small branch of the Ohio, immediately below a rather long, quiet pool.

Fusconaia flava parvula Grier (1918).

Unio rubiginosus Norris, 1902, p. 119 (Winona Lake); *Quadrula rubiginosa* Ortmann, 1909*b*, p. 203 (Lake Erie); *Quadrula undata* (*pars*) Walker, 1910*b*; *Quadrula undata* (*pars*) Simpson, 1914, p. 880; *Fusconaia flava parvula* Grier, 1918, p. 11.

Plate II, fig. 2.

Previously reported as a *distinct* form, only by Grier (1918) but referred to by Ortmann, 1909*b*, p. 203, as *Quadrula rubiginosa.*

Characters of variety: Much smaller than *F. flava* and *F. flava trigona,* generally less than half their size and bulk. The shape of this form is much like that of the var. *trigona* (subtrapezoidal), although sometimes there are found more triangular specimens, which incline towards the western *F. flava undata.* With regard to the swelling of the valves, there is great variety, some specimens being almost as flat as the normal *F. flava,* but on the average, the swelling, and also the development of the beaks, is more like that of *F. flava trigona,* with the diameter generally over fifty percent of the length. Color of epidermis, when young, rather light, yellowish brown (in Lake Erie), or greenish brown (in Winona Lake), with very distinct and regular, dark growth-rests, and fine, indistinct greenish or brownish rays. Old shells become darker, chestnut-brown or greenish black (the latter is the case in Winona Lake). Old specimens are sometimes unusually drawn out at the lower posterior end, and thus become oblique.

		L.	H.	D.	Pr.ct.
Size:	1. Erie, Cat. No. 61.3886	59 mm.	49 mm.	31 mm.	.53
	2. do. Cat. No. 61.4371	57 "	49 "	33 "	.58
	3. do. Cat. No. 61.4513 (Type set)	52 "	41 "	27 "	.52
	4. do. Cat. No. 61.4370	41 "	35 "	23 "	.56

The first two shells are very old, the largest at hand, and they are much drawn out posteriorly; the third and fourth are good average specimens.

Soft parts: They have been alluded to by Ortmann (1912, p. 241), under *F. undata.* A gravid female with young glochidia was subsequently secured from Cedar Point, Ohio, and, as far as could be made out, the *glochidia* agree in shape and size with those of *F. flava.*

Breeding season: Gravid females were found in Presque Isle Bay on July 8, 9, and 12, 1910. They did not have glochidia. The specimen from Cedar Point with young glochidia was collected July 24, 1911.

Remarks: This is the Lake Erie form of *F. flava,* and a similar form is found in Winona Lake in Indiana. The latter agrees in size, and also in general shape, although the tendency toward the triangular shape of *F. flava undata* is more pronounced. It is, however, more greenish brown in color, while specimens from Lake Erie are more yellowish or rusty brown. One specimen from Winona Lake is as flat as *F. flava.*

The variety from Lake Erie is quite distinct, characterized chiefly by its small, dwarfed size, and by having more distinct and regular growth-lines, a

feature noticeable in almost all species found in Lake Erie. In other respects this variety is rather indifferent; it inclines most toward the var. *trigona*, but there is a tendency in some individuals to become more triangular (with higher beaks), like *F. flava undata*. With regard to obesity, it is very variable, and some specimens are as flat as *F. flava;* in fact, young specimens are very often found, which are indistinguishable from young *F. flava*.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pa.; and also in Horseshoe Pond on Presque Isle.

Lake Erie, Crystal Beach, Welland Co., Ontario, Canada (F. Behrle); Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich); Sandusky Bay, Cedar Point, Erie Co., Ohio (O. E. Jennings); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).[19]

Distribution and Ecology (See fig. 3): *Type locality*, Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania. *Type set:* Carnegie Museum, Cat. No. 61.4513.

Aside from the range indicated by the above localities, no details are known. Walker (1910*b*, p. 22) mentions that *Quadrula undata* has invaded the St. Lawrence system, and that it is found in the lake-drainage in Wisconsin, Illinois, and southern Michigan, and that it goes eastwards as far as Buffalo, New York, and Port Dover, Ontario (in Lake Erie); and in 1913, Walker cites both *rubiginosa* and *undata* from Lake Erie, but the form from Lake Erie has not been discussed in detail. We do not know whether the var. *parvula* is restricted to the lake, or also found elsewhere. Marshall (1895, pp. 89 and 93) calls the Lake Erie form from New York both *rubiginosa* and *trigona*.

As far as my material goes (I have seen over fifty specimens from Lake Erie) *F. flava parvula* is a well-marked local form, easily distinguished from the other phases of the species. However, it would not be astonishing if it should pass elsewhere into the other forms, in fact, the shells from Winona Lake represent to a degree transitions both toward *F. flava* and *F. flava undata*.

Possibly the dwarf form of *Quadrula rubiginosa* from Tippecanoe and Kuntz Lakes in northern Indiana, mentioned by Wilson & Clark (1912*a*, p. 43), difficult to distinguish from *trigona*, belongs here.

The mutual connection of the three forms described above has hitherto been misunderstood, and some authors have been quite emphatic in the assertion that *rubiginosa* (= *flava*) should not be united specifically with *undata* or *trigona* (Call, 1895; Walker, 1910*b*). But upon the basis of my own studies of the conditions in western Pennsylvania, I am as emphatic in maintaining that *flava* is only the

[19] These were received as "*coccinea*," but undoubtedly correspond to "*rubiginosa*" of Norris' list (1902) from Eagle (= Winona) Lake.

creek-form of the river-form *flava trigona*. As I have pointed out under *flava trigona*, the latter has (or had) in the Ohio and Monongahela near Pittsburgh a distinct tendency to become more flattened. There are all intergrades in this respect before me, and it is absolutely impossible to draw a natural line between the swollen *trigona*-form, and the flat *flava*-form. Farther up in the Monongahela and Allegheny, and in their tributaries, and also in the smaller tributaries of the Ohio proper, the pure and typical *F. flava* is exclusively found.

Conditions like these force us to unite these forms specifically. But nevertheless *trigona* is to be regarded as a distinct variety, constituting a geographical, or rather ecological, race of *F. flava*, which has its definite habitat in larger streams. There are indications that similar conditions prevail outside of Pennsylvania.

Attention should be called to the singular parallelism of these forms with those of the *Fusconaia subrotunda*-group. In the latter, we have seen that there is a greatly swollen form, with highly elevated and incurved beaks (*F. ebena*) living in the largest, deepest rivers, with muddy bottoms, and therefore in those regions, which are nearest to the center of the interior basin. In the great rivers with sandy and gravelly bottoms and somewhat stronger current, that is to say in the upper Ohio, this is replaced by a form, which, although more or less swollen, has less elevated beaks (*F. subrotunda*). This in turn in the smaller streams gives way to a flat form (*F. kirtlandiana*). The same is true apparently in the *F. flava*-group. We observe a very swollen form with high beaks having the Mississippi as the center of its range (*F. undata*); a swollen form with less elevated beaks in the upper Ohio (*F. trigona*); and a flat form in the smaller creeks (*F. flava*). To these is added, in this case, a dwarfed lake-form in Lake Erie (*F. parvula*).

The boundaries of these corresponding forms of the two series do not coincide, inasmuch a *F. subrotunda* goes farther up in the rivers than does *F. flava trigona*.

It is well to keep this peculiar phenomenon in mind, for later on we shall become acquainted with other instances of the same kind.

Further, attention should be called to the peculiar fact that, while the form *flava* is entirely missing in northwestern Pennsylvania, and is represented in Lake Erie by the form *parvula*, it turns up again in western New York. The Carnegie Museum has specimens from the environs of Rochester, New York, and it had been previously reported from the region of Buffalo and the Erie Canal, from the Genesee River and the Mohawk, crossing over to the Atlantic slope (See Call, 1878, and 1885; Dewey, 1856; Marshall, 1895; Baker, 1898*b*). According to Call, it has migrated along this route in recent times. Since this range has no connection with the rest of the range of *F. flava*, we must assume that it came

into this region from Lake Erie near Buffalo, and that it is the form *parvula* which originally entered the tributaries and canal, but which under the changed environment, again assumed the shape and the characters of the form of the creeks, called *flava*. This is a very interesting phenomenon, and appears to indicate the very important influence of environment upon the shape of the external characters of the shell. If this were the only instance of the kind, we might regard it with suspicion, but we shall become acquainted with other facts of a similar nature, and in order not to loose sight of this instance, it is emphasized here.

Finally attention should be directed to the great tendency to develop local forms within the *flava*-group. Although we have distinguished only four main forms (*undata, trigona, flava, parvula*) some of these include several local types. For instance, the *flava* of the Allegheny River and Crooked Creek in Pennsylvania is distinguished by small size, while in the creeks of southwestern Pennsylvania a much larger form prevails. In the Little Kanawha River in West Virginia is a very peculiar race of *flava*, distinguished by a shape, which is considerably drawn out at the lower posterior end. A peculiar small race of *trigona* is found in Elk River, West Virginia, and the forms from Arkansas also have certain characteristics of their own. These conditions are very interesting, but can be studied only with the help of larger series from the different localities.

Genus Amblema Rafinesque (1820).

Crenodonta Ortmann, 1912, p. 245; *Crenodonta* (Schlueter) (section of *Quadrula*) Simpson, 1914, p. 813; *Amblema* Frierson, 1914*a*, p. 7; *Amblema* Utterback, 1916, p. 31.

Type *Amblema costata* Rafinesque.

Only one species, *A. plicata*, is found in Pennsylvania, within which, however, two well-marked races may be distinguished.

Key to the forms of A. plicata.

a_1. Shell smaller, generally more swollen, less elevated posteriorly. Sculpture less developed, chiefly so upon the posterior slope..... *A. plicata.*

a_2. Shell larger, generally more compressed, and more elevated posteriorly. Sculpture better developed, chiefly so upon the posterior slope..... *A. plicata costata.*

Amblema plicata (Say) (1817).[20]

Quadrula plicata hippopæa (Lea) Simpson, 1914, p. 816; *Amblema plicata* (Say) Utterback, 1916, p. 33.

[20] Not 1816, as given by Simpson. (See Binney, Bibliography, 2, Smithsonian Miscell. Coll., 9, 1869, p. 277.)

Plate II, figs. 4, 5, 6.

Records from Pennsylvania:

Reported previously from Lake Erie, but not from the Pennsylvanian shores, except by Ortmann (1909*b*, p. 203) as *undulata hippopæa*.

Characters of the Shell: Shell of medium size, rather heavy. Outline suboval to subtrapezoidal, generally slightly longer than high, somewhat oblique, rounded before, subtruncate behind. Beaks moderately prominent. Beak-sculpture consisting of three to five concentric ridges, slightly angular and nodulous behind; only one to three are distinct, the others indistinct, often indicated only by the nodules. The beak-sculpture is not continued upon the disk. Shell moderately swollen, with indistinct, rounded posterior ridge. Surface sculptured by transverse, oblique folds or undulations, which run parallel to each other in the direction of the lower posterior end. These folds are absent in very young shells, and begin in older individuals at a certain distance from the beaks, and at, or a little in front of, the middle of the disk, leaving the anterior part of the shell free. These folds are very variable, sometimes hardly indicated, in other cases they are rather strong. In large shells, there are as many as four or five of them. Posterior slope comparatively narrow, since the upper posterior margin is only little, or not at all elevated, so that the posterior wing is only slightly developed. In younger shells, however, it is generally well-developed. The posterior slope is often entirely smooth, but sometimes there are indications of radiating folds or ribs, smaller than those upon the middle of the disk, and occasionally they may become rather distinct and strong. In the latter case they have no distinct relation to the large folds, but seem to diverge from the uppermost of the latter at an angle. Epidermis in young specimens yellowish or greenish brown, rather light, without rays. Growth-lines dark. In old shells the epidermis becomes darker, reddish or chestnut-brown to blackish, and the growth-rests, which are rather regular, become less marked in color.

Hinge-teeth strong, ragged. Pseudocardinals divergent. Interdentum moderately developed. Lateral teeth strong and rather long. Beak-cavity of medium depth. Dorsal muscle-scars on the hinge-plate. Nacre white, posteriorly often very beautifully iridescent with purplish and pinkish reflections. No difference whatever between the male and female shell.

		L.	H.	D.	Pr.ct.
Size: 1. Erie, Cat. No. 61.4520 (largest, ♀)		98 mm.	71 mm.	40 mm.	.41
2. do. Cat. No. 61.4520	(♂)	68 "	54 "	30 "	.44
3. do. Cat. No. 61.4516	(♂)	46 "	36 "	20 "	.43

Soft parts (See Ortmann, 1912, p. 246). *Glochidia* unknown.

Breeding season: Of this form, I have found only two gravid females, with eggs, on July 8, 1910. The eggs were white.

Remarks: The nomenclature of this species and its forms has been erroneous hitherto, and the original *U. plicatus* of Say has been entirely misunderstood by practically all authors, except Utterback (1916). Indeed, from Say's description alone it is impossible to decide what form of the *plicata*-group he had before him, but the locality he gives, Lake Erie, settles the case. There is no other form of the *plicata*-group in the lake,[21] except this, and consequently the common form from Lake Erie should bear this name, and not that of *hippopæa* given by Lea.

A. plicata of Lake Erie is not the normal type of the species, but is a dwarfed form of a species of the Ohio-drainage (*costata*). Thus nomenclature reverses the natural conditions, making out of a local race the typical form of the species, but this cannot be helped. The differences of *A. plicata* from the Ohio-form *costata* are very slight, in fact, the only reliable distinction is the size, but there are a few others, which may be more or less depended upon. The typical *plicata* is generally more oval, and the posterior part (wing) is not so elevated. Furthermore the growth-lines are more regular and closer together, the shell is slightly more swollen on the average, and the color lighter. But in young specimens all these characters are more or less obscured, and it is practically impossible to distinguish these two forms in the juvenile stage. I have young *costata* which may be matched with young *plicata*, without showing the slightest difference.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, Cedar Point and Sandusky Bay, Erie Co., Ohio (O. E. Jennings and Chas. Brookover).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Distribution and Ecology (See fig. 4). *Type locality:* Lake Erie (Say).

This species is known in Pennsylvania only from Lake Erie. In Presque Isle Bay it is rather abundant, and at certain places sometimes great numbers of young shells are found in one to two feet of water. The larger specimens are generally found at a depth of three to four feet, and with the clam-dredge I obtained some at five feet, and others were brought up by the "sand-sucker" from a depth of ten to fifteen feet. They are found generally in fine sand and gravel, but I also found a few on the southern shore of the bay (mainland), where the bottom consists of coarse shingle.

[21] I have received, from L. S. Frierson, a true *A. plicata costata* from Maumee Bay at the mouth of the Ottawa River, near Toledo, Lucas Co., Ohio. This however, is a dead shell, and may have been washed into the lake from the Ottawa or Maumee Rivers, in both of which *A. plicata costata* is present.

Outside of Pennsylvania this species has been recorded only from those states which border on Lake Erie. It is known from Buffalo, New York (Marshall, 1895, p. 50), but said to be identical with *U. undulatus* (= *A. costata*). It is given

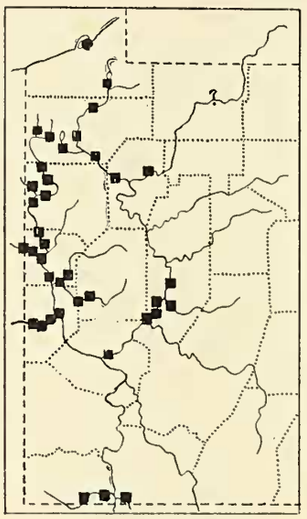


Fig. 4.
● *Amblema plicata.*
■ *Amblema plicata costata.*

from the Ohio shores of the lake by Sterki (1907*a*), and from the shores in southeastern Michigan (Walker, 1898), and from Lake Erie in general (Walker, 1913).

The record from Lake Winnipeg, Canada (Hanham, 1899) should be questioned for the present.[22]

Amblema plicata costata (Rafinesque) (1820).

Quadrula undulata (Barnes) Simpson, 1914, p. 819;[23] *Quadrula costata* (Rafinesque) Vanatta, 1915, p. 556; *Amblema plicata costata* (Rafinesque) Utterback, 1916, p. 33.

Plate II, fig. 7; Plate III, figs. 1, 2, 3.

Records from Pennsylvania:

Clapp, 1895 (Allegheny Co.).

Marshall, 1895 (Allegheny River, Warren Co.).[24]

Rhoads, 1899 (Ohio River, Beaver Co., and Beaver River, Wampum, Lawrence Co.) (as *plicatus*).

Ortmann, 1909*b*, p. 198.

[22] Simpson (1900, p. 769, footnote 3) mentions a peculiar form of "*undulata*" from Lake Winnipeg. Possibly this is the same as that referred to by Hanham, and might be a form parallel to *plicata*.

[23] Simpson makes a singular mistake in quoting, among the synonyms, *Unio undulatus* Sowerby, 1868, Pl. 76, fig. 399, which probably is *Alasmidonta undulata* (Say).

[24] I did not find this form so far up in the Allegheny, but only as high up as Venango Co., where it is very rare. But it may have extended farther up in the past.

Characters of variety: This form differs from *plicata* of Lake Erie by being considerably larger, attaining a huge size; in fact it is one of our largest and heaviest shells. The shell is generally rather flat, with the diameter less than forty percent of the length, and the posterior wing is well-developed, so that the upper margin appears elevated posteriorly. The beaks are very slightly prominent. The surface sculpture is similar to that of *plicata*. In large specimens there are upon the sides four or five transverse bars, but they are, as a rule, more distinct and broader than in *A. plicata*. The radiating ribs upon the posterior slope and the wing are more frequently and more distinctly developed. Color of epidermis generally darker, although young shells are often as light as *plicata*. The growth-lines are less regular, and old shells become uniformly black. Nacre white, often beautifully iridescent posteriorly. No difference between the male and the female in the shell.

	L.	H.	D.	Pr.ct.
Size: 1. Jamestown, Cat. No. 61.3831	161 mm.	123 mm.	68 mm.	.42
2. Mahoningtown, Cat. No. 61.3830	99 "	78 "	38 "	.38

No. 1 is the largest specimen on hand.

Soft parts and *Glochidia* (See Ortmann, 1912, p. 246).

Breeding season: Typically tachytictic, breeding from May to July. I found gravid females on the following dates: May 13, 1911; May 17, 1910; May 23, 1911; May 23, 1912; May 23, 1914; May 24, 1911; June 19, 1909; July 3, 1908; July 8, 1909; July 10, 1909; July 10, 1911. Glochidia were seen only in July, and a discharging specimen was observed on July 10, 1911. Wilson & Clark (1912*a*) report gravid specimens as late as July 28.

Remarks: Amblema plicata costata undoubtedly is the parent form, from which *A. plicata* is derived as a depauperate form in Lake Erie. The former is rather variable in some of its characters, but it is always much larger, generally more compressed, and the posterior wing is more elevated. The sculpture varies a good deal. I have specimens in which the shell is practically smooth, without any folds (Compare the figures of Baker, 1898*a*, Pl. 12, fig. 1; Smith, 1899, Pl. 82, and our figs. 2 and 3 on plate III). Sometimes the folds are peculiarly developed, showing a tendency to be divided into nodes. I have even a specimen in which these nodes form irregular vertical ribs, running toward the lower margin of the shell, so that, together with the ribs of the posterior slope, a system of low bars is indicated, which diverge from the posterior ridge of the shell in the direction of the lower and posterior margins.

The specimens from Pennsylvania are all to be regarded as true *costata*, and I have not seen any forms which incline toward the western and southwestern

representatives; nevertheless there is a tendency in this form to become more swollen in the larger rivers (See Pl. III, figs. 2, 3).

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Marcer Co.; Linesville, Crawford Co.
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp, H. H. Smith, & G. L. Simpson, Jr.); Zelienople, Harmony, Butler Co.
Slippery-rock Creek, Wurtemberg, Lawrence Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Padan Creek, Linesville, Crawford Co. (O. E. Jennings).
Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, and Mosgrove, Armstrong Co.; Walnut Bend, Venango Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Dunkard Creek, Dunkard, Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Locality in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Beaver, Beaver Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Lake-drainage:

Tonawanda Creek, Erie Co., New York (Smith collection).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids and Otsego Rapids, Wood Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Silver and Beaver Creeks, Williams Co., Ohio (C. Goodrich).
St. Mary's River, Rockford, Mercer Co., Ohio (C. Goodrich).
Ottawa River, Lucas Co., Ohio (C. Goodrich)..
Lake Erie, Maumee Bay, at mouth of Ottawa River, Lucas Co., Ohio (L. S. Frierson donor).[25]
Raisin River, Grape P.O., Monroe Co., and Adrian, Lenawee Co., Michigan (C. Goodrich).
Rouge River, Wayne Co., Michigan (C. Goodrich).
Gratiot Co., Michigan (C. Goodrich) (Saginaw drainage).

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; St. Mary's, Pleasants Co., and Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.
Conotton Creek, New Hagerstown, Carroll Co., Ohio.
Tuscarawas River, Ohio (Holland collection).

[25] A dead shell, probably washed into the lake from the river.

Wolfe Creek, Washington Co., Ohio (W. J. Graham).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Big Beaver Creek, Mercer Co., Ohio (C. Goodrich).
Wabash River, New Corydon, Jay Co., Geneva, Adams Co., and Bluffton, Wells Co., Indiana (C. Goodrich).
West Fork River, Lynch Mines, Harrison Co.; Milford, Harrison Co. (W. J. Graham); Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. J. Graham) and Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Harrisville (W. J. Graham), and Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton, Clay Co., and Gassaway and Sutton, Braxton Co., West Virginia.[26]
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

French Broad River and Boyd Creek, at Boyd Creek, Sevier Co., Tennessee.
Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.
Holston River, Hodges, Jefferson Co.; Turley Mill and Noeton, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia.
Clinch River, Solway, Knox Co.; Clinton and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia.
Emory River, Harriman, Roane Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee.

From upper Mississippi northwards and westwards:

Little Muddy Creek, DuBois, Washington Co., Illinois (A. A. Hinkley).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards) (drainage of Red River of the North).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
Terre Noir Creek, Mount Zion, Clark Co., Arkansas (H. E. Wheeler).

All the above specimens are to be considered as typical *A. plicata costata*. Other sets from Indiana, Illinois, northern Alabama (Tennessee-drainage), Kansas, Arkansas, and Oklahoma, show peculiar features, leading to the western and southern representatives of this form. I cannot go into detail here, yet it should be mentioned that I have from the Alabama drainage one set, which cannot be distinguished from *costata*. It is from Valley Creek, Toadvine, Jefferson Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 4): This form is not rare in our state. It is found in the larger streams as well as in their tributaries, and in general is most abundant in some of the latter. In the Ohio below Pittsburgh it is not very plentiful; in the Monongahela proper it has not been found, and it is decidedly rare in the Allegheny. But it turns up again in some of the tributaries

[26] In the Kanawha drainage, I have seen a dead shell in Coal River, Sproul, Kanawha Co., W. Va.

of the Monongahela, and is abundant in its headwaters in West Virginia. In the Beaver-drainage it is nearly everywhere, being absent only in the smaller creeks. The same is true of French Creek.

It is generally found in the more or less coarse gravel of our streams, often in the Allegheny and Ohio among very heavy gravel and in strong currents, but it is by no means averse to fine gravel and sand (chiefly so when young). It avoids mud, as most of our Naiades do. The shell attains considerable size, and there is no relation between the size of the stream and that of the shell, very large individuals having been often found in small creeks.

General Distribution: Type locality, Ohio River (Rafinesque); according to Vanatta small creeks in Kentucky.

The range outside of Pennsylvania is very extended, and comprises practically the whole of the Ohio-drainage, including the Tennessee-Cumberland system, and westward, the Mississippi- and Missouri-drainages to Minnesota, Iowa, Nebaska, Kansas, and Oklahoma. Northwards it crosses into the drainage of the Great Lakes at several points, and has been reported as occurring as far northeast as Ottawa, Canada (Simpson, 1893, p. 592). It is found in western New York in Erie, Niagara, Monroe, and Onondaga Cos. (Marshall, 1895) in tributaries of the St. Lawrence system and along the route of the Erie canal. This group of localities, confirmed also by our specimens from Tonowanda Creek, is important (see below). It is not found in Lake Erie proper, being there replaced by *A. plicata.*

In Ohio it is present in both drainages (Sterki, 1907*a*), and has been repeatedly reported from streams running to Lake Erie; from the Cayuga, Rock, and Sandusky Rivers (Dall & Simpson, 1895), and also from the Maumee River (Carnegie Museum). This establishes one route of migration from the Ohio to the lake. It is furthermore found in southern Michigan (Walker, 1898). It also crosses over in the north into the Red River of the North and the Lake Winnipeg-drainages.

Towards the south and southwest, the boundaries of the range of the true *A. plicata costata* are poorly known. It certainly exists in tributaries of the Cumberland in Tennessee (Wilson & Clark, 1914), and in the headwaters of the Tennessee in eastern Tennessee and Virginia (Carnegie Museum). But farther in this direction it is replaced by the southern form (*perplicata*). In Arkansas and Oklahoma forms intergrading with the latter are found.

From the middle Ohio (region of Cincinnati) downward, and in the Mississippi River, its place is largely taken by the closely allied *Amblema peruviana* (Lamarck),[27]

[27] This is the *Quadrula plicata* of Simpson (1914, p. 814).

but particulars about the distribution of this form are scarce. As far as can be judged, *A. peruviana* seems to prefer the largest rivers, and probably muddy bottoms. In the Ohio from the Pennsylvania state line down to Portsmouth, Ohio, I have never seen a true *peruviana*.

In the distribution of the forms of the *A. plicata*-group two facts should be especially emphasized.

1. We have here a group of at least three forms: a dwarfed form from Lake Erie (*A. plicata*); a flat form found in the smaller rivers and headwaters (*A. plicata costata*); and a swollen form with high beaks in the largest rivers (*A. peruviana*). Only the first two are found in Pennsylvania, but the third turns up in the Ohio in the neighborhood of Cincinnati. These conditions correspond in a degree to what we have observed in two cases in the genus *Fusconaia* (See above, pp. 14 and 24).

2. In western New York, we have the typical form from small rivers, (*costata*) tributaries of the St. Lawrence system, apparently entirely isolated from the rest of the range, for this form is positively absent in the uppermost Allegheny-drainage. The form found in Lake Erie is not this, but *A. plicata*. Thus it seems that western New York has been colonized from the lake, the lake-form (*plicata*) again assuming the river form (*costata*). This case should be compared with what we have learned about *Fusconaia flava* (See p. 25).

Genus Quadrula Rafinesque (1820).

Ortmann, 1912, p. 250; Simpson, 1914, p. 811.

Type *Obliquaria metanevra* Rafinesque.

Five well-defined species and one variety are found in Pennsylvania.

Key to the Species and Varieties of Quadrula.

a_1. Shell more or less regularly rounded, with tubercles, which are rather small and irregularly scattered, and have no connection with the weakly developed, concentric beak-sculpture. Epidermis yellow to brown, rayed, when young, rays green, often very broad and broken up into large spots.

b_1. Shell rounded, high, not transverse. Posterior wing not developed. . . . . *Q. pustulosa.*

b_2. Shell more transverse. Posterior wing better developed. . . . . *Q. pustulosa schoolcraftensis.*

a_2. Shell not rounded, but trapezoidal, triangular, or elongated. Sculpture consisting of tubercles, knobs, or ribs, of a more or less definite arrangement, more or less related to the beak-sculpture; the latter double looped or of the zig-zag type. Epidermis rayed in various patterns or spotted.

b_1. Shell subtrapezoidal, with a narrow and blunt posterior ridge. In front of the latter a broad and shallow groove. Tubercles of posterior ridge not very large. Epidermis with irregular rays, rays often spread out, but not spotted.

e_1. Shell about as long as high. Groove of disk distinct, generally without nodules. *Q. quadrula.*

c_2. Shell much longer than high. Groove of disk shallow, and covered with the same nodules as the anterior part of the shell.....*Q. verrucosa.*

b_2. Shell subtrapezoidal, with a broad and distinct posterior ridge. In front of this ridge, and behind, a slight depression, but no distinct radial groove. Tubercles of this ridge generally large. Rays of epidermis generally broken up into characteristic spots.

c_1. Shell subtrapezoidal or subrhomboidal, about as high as long. Sculpture of disk generally well-developed.....*Q. metanevra.*

c_2. Shell subrectangular, much longer than high. Sculpture of disk often poorly developed. *Q. cylindrica.*

Quadrula pustulosa (Lea) (1831).

Quadrula pustulosa (Lea) Simpson, 1914, p. 848.

Plate III, figs. 4, 5.

Records from Pennsylvania:

Harn, 1891 (Western Pennsylvania).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 199.

Characters of shell: Shell of not more than medium size, but rather heavy. Outline subcircular, or obovate, about as high as long, not oblique, but rather upright. Beaks moderately prominent. Beak-sculpture consisting of two to three indistinct, concentric ridges, slightly angled and nodulous behind, not continued upon the disk. Shell from rather swollen to rather flat, evenly convex, without, or with very indistinct, posterior ridge. Basal margin evenly rounded. Surface sculptured by very irregular and variable nodules or pustules, absent towards the beaks. Sometimes the surface remains entirely smooth, but generally the pustules begin at a certain distance from the beaks, and are larger or smaller, rounded or transverse. Upon the posterior slope they are absent or present, and, when present, generally smaller, and often arranged in radiating ribs, or they are entirely rib-like. Epidermis yellowish brown to brown, when young, generally with distinct green rays, one of which is characteristically broad, sometimes interrupted so as to form blotches. Growth-rests dark brown.

Hinge-teeth heavy, more or less ragged. Pseudocardinals slightly divergent. Interdentum present, narrower or broader. Lateral teeth rather strong and short. Beak cavity rather deep. Dorsal muscle scars upon the hinge plate. Nacre always white. No difference whatever between the male and female shell.[28]

	L.	H.	D.
Size: Kelly, Cat. No. 61.4365 (largest at hand, ♂).....	72 mm.	70 mm.	36 mm.

[28] Call (1896*a*, p. 43) says that "the female is often somewhat emarginate." This is not always so in the females at hand; in fact this slight emargination of the posterior margin, which is actually often observed in this species, has no relation to sex.

Soft parts (See Ortmann, 1912, p. 251). *Glochidia* figured by Lefevre & Curtis (1910, p. 97, fig. F, and 1912, p. 146, fig. F), 0.23 × 0.32 mm.; by Surber (1912, Pl. 2, fig. 20) 0.23 × 0.29 mm., and by Howard (1914, Pl. 5, fig. 36). I have seen them in specimens from West Virginia and Arkansas, and found them to vary somewhat in size: 0.21 × 0.26 mm. (Arkansas), and 0.22 × 0.29 mm. (West Virginia). They are rather large for the genus.

Breeding season: Gravid females have never been observed in our state, but I have them from Arkansas, collected on May 19, 1911, and July 19, 1913, and from West Virginia, collected July 10, 1911. In the upper Tennessee region, I found them on May 25, 1914. This is probably a summer breeder (tachytictic).

Remarks: This species is well-distinguished by the general shape and sculpture, although the latter is often poorly developed and even absent (chiefly in young specimens). The sculpture always begins at a certain distance from the beaks, and does not represent a continuation of the beak-sculpture. In its general character, this sculpture resembles that of certain species of other genera, chiefly of *Plethobasus cooperianus* (Lea), and there are cases, where it is hard to distinguish these two species by the shell alone. However, *P. cooperianus* is generally more oblique, and the nodules are rather distinctly confined to the posterior half of the shell. Of course, they are easily told apart, when the soft parts are at hand.

The shells from the Ohio-drainage in Pennsylvania are undoubtedly all typical *Q. pustulosa*. But outside of our state this species varies greatly, not only in sculpture, but also in shape. These variations are in part geographical, and have been named, but cannot be discussed here.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry and Industry, Beaver Co.; Neville Island, Allegheny Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown and Edinburg, Lawrence Co.
Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).
Cheat River, Cheat Haven, Fayette Co.
Allegheny River, Natrona, Allegheny Co.; Godfrey and Kelly, Armstrong Co.

Locality in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Coraopolis, Allegheny Co. (S. N. Rhoads).

Other localities, represented in the Carnegie Museum:

Ohio-Mississippi-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Little Kanawha River, Grantsville, Calhoun Co. (F. W. Graham); Burnsville, Braxton Co., West Virginia.

Elk River, Shelton, Clay Co., West Virginia.

Poeatalieo River, Raymond City, Putnam Co., West Virginia.

Little Coal River, Boone Co., West Virginia (Hartman eollection).[29]

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentueky.

Lieking River, Farmer, Rowan Co., Kentueky.

Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

Mississippi River, Museatine, Museatine Co., Iowa (Hartman eollection); and Moline, Roek Island Co., Illinois (P. E. Noordgren).[30]

Tennessee-drainage:

Tennessee River, Florenee, Lauderdale Co., and Tuseumbia, Colbert Co. (H. H. Smith); Bear Creek, Burleson, Franklin Co. (H. H. Smith); Shoals Creek, Lauderdale Co. (H. H. Smith); Paint Roek River, Paint Roek, Jaekson Co., Alabama (H. H. Smith).

Tennessee River, Coneord and Knoxville, Knox Co., Tennessee.

Freneh Broad River, Boyd Creek, Sevier Co., Tennessee.

Noliehueky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, MeMillan and Maseot, Knox Co.; Hodges, Jefferson Co., Tennessee.

Clineh River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co., Tennessee.

Speeimens from the Blaek River and Ouaehita River in Arkansas do not represent the typieal phase of *Q. pustulosa:* they require further study. (See: Wheeler, 1918, p. 123.)

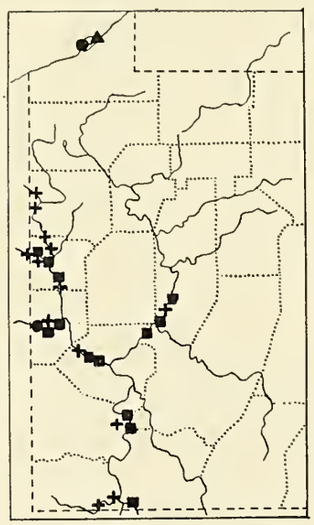


Fig. 5.

■ *Quadrula pustulosa.*
▲ *Quadrula pustulosa schoolcraftensis.*
● *Quadrula quadrula.*
\+ *Quadrula verrucosa.*

[29] Labeled " Little Coal River, Logan Co., Virginia," but this river does not flow through Logan Co.

[30] The speeimens from the Mississippi River differ somewhat from the typieal form in having a better developed posterior wing and somewhat more prominent beaks, so as to intergrade toward *Q. dorfeuillana* (Lea).

Distribution and Ecology in Pennsylvania (See fig. 5): This is one of the rarer species in Pennsylvania. It occurs in the Ohio and Monongahela, in the latter as far up as the lower Cheat River, but it is missing in the headwaters of this system in West Virginia. In the Allegheny River, it has been traced up into Armstrong Co., and, in addition, it is found in the Beaver and Mahoning Rivers, but has not been found in the Shenango.

In all the other streams, not mentioned, it is absent, and thus its ecological preferences are decidedly with the larger streams; but since it has not often been found alive, details are scarce. I collected it myself in the heavy gravel of the Ohio, Allegheny, and Cheat, as well as in coarse gravel in the Mahoning. On similar bottom I found it in the Little Kanawha and Elk Rivers in West Virginia, and in the upper Tennessee region. But in Pocatalico River I found it in pure sand. In the Ohio in West Virginia and Ohio, it is abundant on the " shell banks," in deep, strongly flowing water, with gravelly bottom, and here it is frequently taken by the clam-diggers. Call (1900, p. 488) reports this species from muddy bottoms as well as from sand and gravel bars.

General distribution: Type-locality, Ohio (Lea). This species is quite characteristic of the Ohio proper and its larger tributaries. It also belongs to the Cumberland and Tennessee-drainages, and is there in its typical phase, but some confusion exists as to this.[31] In the states of Ohio, Indiana, and Illinois it is a common shell (Sterki, 1907*a*, Call, 1896*a*, and 1900, Baker, 1898*a* and 1906). How far it extends West and Southwest is hard to say, but the typical form has been figured by Scammon (1906) from Kansas. In this region, however, it is in part represented by more or less distinct varieties. Among the material at hand, there seem to be several of the latter, but I am well acquainted only with one (var. *schoolcraftensis*, see below).

Note: This species is only moderately swollen, or even rather flat, in Pennsylvania. Farther down the Ohio more distinctly swollen individuals are met with, becoming sometimes almost globular, culminating finally in the type known as *dorfeuillana* Lea (with high beaks). This indicates a tendency similar to that observed in several of the preceding species, which, however, is in this case not so distinctly marked, since *Q. pustulosa* does not go up, as a rule, into small streams.

[31] The chief mistake has been made by Simpson (1900, p. 780) in stating that the varieties *pernodosa* Lea and *kieneriana* Lea (not *keineriana*) are found in streams " draining into the Gulf of Mexico," while the type-locality of *pernodosa*, at least, is in the upper Tennessee drainage. A singular double mistake is made by Sterki (1907*a*, p. 391) in quoting " *kleineriana* " (for *kieneriana*) from Lake Erie.

Quadrula pustulosa schoolcraftensis (Lea) (1834).

Quadrula pustulosa schoolcraftensis (Lea) Simpson, 1914, p. 850.[32]

Plate III, figs. 6, 7.

Never before reported from Pennsylvania.

Characters of variety: Distinguished from typical *pustulosa* by the more transverse and subquadrate outline. This is brought about by a stronger development of the posterior wing, and the shell thus appears more elongated, and less high. In addition, the posterior ridge appears more distinct, the color of the epidermis is generally lighter, and the nodules are rather poorly developed, but the latter characters are inconstant.

Size:	L.	H.	D.
1. Erie, Pennsylvania, Cat. No. 61.4515 (old ♀, much elongated)	72 mm.	52 mm.	36 mm.
2. Cedar Point, Ohio, Cat. No. 61.4451 (normal)	49 "	41 "	26 "

Soft parts agreeing with those of the typical form (Ortmann, 1912, p. 251) *Glochidia* and *breeding season* not observed.

Remarks: The characteristic feature of this form, the transverse shape, has been sufficiently emphasized by the earlier authors, but later on it was unconditionally thrown together with *pustulosa* (Call, 1900; Simpson, 1900). Sterki (1907*a*, p. 291), however, has again correctly recognized it, and Simpson follows him (1914). I also believe that it is a distinguishable form, but there are intergrades with the normal *pustulosa*. In our region, *schoolcraftensis* is quite distinct, and does not come together geographically with the typical form. But this is the case elsewhere. Baker (1898*a*, Pl. 24 and 25) has given a number of figures, some of which are evidently *pustulosa*, but at least one is an undoubted *schoolcraftensis*. There are some figures on Baker's plates, which are more or less transitional between the two, and such specimens are also represented in the Carnegie Museum. An example is a fine large specimen from Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren) (L. 64, H. 60, D. 43 mm.). In outline this specimen is intermediate, but on the other hand it is rather smooth and has higher beaks, but not as high as in *dorfeuillana*. In the latter character it resembles some specimens from the Mississippi, taken at Moline, Rock Island Co., Illinois (P. E. Nordgren) and from Muscatine, Iowa, but the latter are not so transverse. (I have recorded these under *pustulosa*.)

Intergrades certainly exist, and as far as I can see at present, they are found in Illinois. They may exist elsewhere. The opinion of Call, Baker, Scammon,

[32] *Unio prasinus* Conrad, made by Simpson a synonym of typical *Q. pustulosa*, belongs here.

and others, that these forms belong to the same species, surely is founded upon the observation of transitions, and I also think that *schoolcraftensis* should not be separated specifically, although the conditions in Pennsylvania would suggest such a step.

It should be mentioned that specimens from Lake Erie show the regular and distinct growth-lines, commonly observed in shells from Lake Erie.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, Cedar Point, Erie Co., Ohio (C. Brookover).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Grand River, Grand Rapids, Kent Co., Michigan (G. H. Clapp donor).
Coon River, Dallas Co., Iowa (Smith collection).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Platte River, Garretsburg, Buchanan Co., Missouri (W. I. Utterback).
Kansas and Wakarusa Rivers, Lawrence, Douglas Co., Kansas (R. L. Moodie).[33]
Chikaskia River, Tonkawa, Kay Co., Oklahoma (F. B. Isely).

In addition, there is a fine large specimen, labeled Poland, Mahoning Co., Ohio, and two others, labeled: Grand River, Ohio, all from the Hartman collection. Those from the latter locality were named *dorfeuillanus*, with the remark: "Lea datum," and thus they are supposed to be authentic specimens from Lea. But I believe, that these localities are unreliable. These specimens are so typically representative of the form from Lake Erie (with very distinct and regular growth-lines) that I think they are undoubtedly from the lake. The fauna of Grand River in Ohio is practically unknown. Poland is near the Mahoning River, and we know, that the typical *pustulosa* is found in the Pennsylvanian part of this river.[34]

Distribution and Ecology in Pennsylvania (See fig. 5): In Pennsylvania, this form has been found only in Presque Isle Bay of Lake Erie, in the characteristic fine sand of the "flats" and the North shore ("Big Bend") of the bay, where the shore is lined with the *Juncus americanus* formation, in one to two feet of water. It appears to be a rare shell there, since only two specimens have turned up.

General Distribution: Type locality, "Fox River of Green Bay" in Wisconsin (Lea). (This belongs to the Lake Michigan-drainage, and is at the same time the most northern locality known.)

From Lake Erie, this form has been reported before as *Q. pustulosa* (Walker, 1913). Aside from the localities given above for the lake, it is found in some of

[33] Some of these specimens, when received, were labeled (by Scammon?) *Quadrula rubiginosa*!

[34] Dean (1890) does not report *pustulosus* from the Mahoning in Ohio, nor does Sterki (1907*a*), but both have *pustulatus* Lea, which is a species not at all found in this region. Probably, Dean's *pustulatus* is only a slip of the pen for *pustulosus*.

the tributaries in Ohio (Tiffin River, Sterki, 1907*a*, and other places in the Maumee-drainage), and is known from the Kankakee in Indiana (Sterki),[35] from Michigan, Illinois, and Iowa (Sterki, 1907*a*, Walker, 1894, as *schoolcraftensis*, and 1898 as *pustulosa*). That it is found in Iowa, is confirmed by the locality given above, and by Call (1895), while Geiser (1910) reports only *pustulosa* from the Wapsipinicon River in northeastern Iowa. The specimens from Missouri and Kansas are fine and typical. Beyond this we do not know much about the distribution of this form, but it is apparent that this variety is more western and northern in its range than the typical *pustulosa*.

It should be noted that the form from Lake Erie hardly differs from the normal type of *schoolcraftensis*, except for the more regular and distinct growth-lines. The route by which it migrated into the lake is indicated by its presence in the Maumee-drainage.

QUADRULA QUADRULA (Rafinesque) (1820).

Quadrula lachrymosa (LEA) SIMPSON, 1914, p. 841; *Quadrula quadrula* (RAFINESQUE) VANATTA, 1915, p. 556; *Quadrula quadrula* (RAFINESQUE) UTTERBACK, 1916, p. 53.

Plate IV, fig. 1.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 199.

Characters of the Shell: Shell growing to a rather considerable size, rather heavy. Outline subtrapezoidal or subquadrate, not oblique, not longer, or only slightly longer than high. Beaks moderately prominent, beak-sculpture double-looped, posterior loop slightly tubercular upon the posterior ridge, these tubercles continued upon the ridge as larger or smaller nodules. Anterior loop, toward the disk, breaking up into nodules, and this sculpture is continued upon the disk in an irregular way. Shell moderately swollen or rather flat, with a rather distinct, but narrow, posterior ridge. In front of the latter, there is a broad, shallow furrow, which is generally smooth, without tubercles. There are large nodules upon the posterior ridge, and smaller ones upon the disk in front of the furrow, but the most anterior part of the shell is generally smooth. Nodules and tubercles very varying in number, arrangement, size, and shape; often they are tear-like (vertically elongated), but they may be transversely elongated. The nodules of the anterior part of the shell are the direct continuation of the beak-sculpture. Posterior slope with more or less distinct nodules, often arranged in radiating ridges.

[35] Specimens from the Kankakee River are cited as *pustulosa* by Wilson & Clark (1912*a*), but they mention the great variability.

Epidermis yellowish to brownish, when young with indistinct rays, and the green color of the rays often spreads out over the shell in indistinct transverse bands or patches (under the larger nodules), so that the whole surface often appears more or less suffused with green. But there are never triangular spots (as in *Q. metanevra* and *Q. cylindrica*). Growth-rests more or less distinct, brownish. Old shells often are uniformly brown, and the sculpture disappears toward the lower margin.

Hinge-teeth moderately strong. Pseudocardinals divergent, ragged; interdentum moderately developed. Beak-cavity moderately deep. Dorsal muscle-scars on hinge-plate. Nacre white. No differences between the male and female shell.

	L.	H.	D.
Size: 1. Cooks Ferry, Cat. No. 61.3869	72 mm.	60 mm.	36 mm.
2. Erie, Cat. No. 61.4526	64 "	52 "	29 "

This species grows considerably larger outside of Pennsylvania.

Soft parts: Ortmann (1912, p. 253). *Glochidia*, figured by Surber (1915, p. 8, pl. 1, fig. 11), remarkably small (0.085 × 0.090 mm.), much resembling those of *Q. verrucosa*. Howard (1914, pl. 5, fig. 29) also gives a figure.

Breeding season: Wilson & Clark (1912*a*, p. 43) report this species as found beginning to become gravid on August 21 in Illinois, and Surber found specimens with glochidia in August in Kansas.

Remarks: The broad, smooth furrow of the disk and the sculpture distinguish this species sufficiently from all other Pennsylvanian forms. The sculpture is very variable, sometimes rather slightly developed, in other cases strong and very prominent. Only a few specimens having been found in our state, no important variations are to be noted. The color-pattern of this species, although quite variable, is characteristic in so far that the rays never break up into well-defined spots.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Cooks Ferry, Beaver Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Miami-Erie Canal, Lucas Co., Ohio (C. Goodrich).
Ohio River, St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portsmouth, Scioto Co., Ohio.
Middle Island Creek, Union Mills, Pleasants Co., West Virginia.
Wolfe Creek, Wolfe P. O., Washington Co., Ohio (W. F. Graham).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Platte River, Garretsburg, Buchanan Co., Missouri (W. I. Utterback).
Lake Contrary, St. Joseph, Buchanan Co., Missouri (W. I. Utterback).[36]
Wakarusa River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Chikaskia River, Tonkawa, Kay Co.; North Fork Canadian River, Weleetka, Okfuskee Co.; Deep Fork Canadian River, Okmulgee, Okmulgee Co., Oklahoma (F. B. Isely).

Distribution and Ecology (See fig. 5). *Type locality:* Ohio River (Rafinesque) according to Vanatta, Salt River, Kentucky.

Two specimens only have been found in Pennsylvania; one in the Ohio River, just above the Ohio state line, the other in Lake Erie. The first was found in sandy-muddy bottom in a quiet eddy in a riffle, the second (a dead shell) in fine sand, the environment characteristic of Presque Isle Bay. According to Baker (1898*a*, p. 85) this species prefers the muddy and sandy bottoms of lakes and larger rivers, and Call (1900, p. 490) calls it a mud-inhabiting shell, while Scammon (1906, p. 252) says that in Kansas it is not particular as to station, but prefers sand. Apparently, it does not find congenial habitats in Pennsylvania, except in Lake Erie and in the Ohio. Its utmost upstream migration has barely reached our state.

Farther down the Ohio, it is also not very abundant, but it is present. In the slack water of the lower part of Middle Island Creek, I have seen a number of dead shells, and here it goes up as far as the slack water, about 5 miles, to just below Union Mills. Also farther down it is not abundant, and distinctly prefers sandy or muddy bottom to gravel. It does not ascend far into the tributaries, but it goes into the lower Muskingum and to Wolfe Creek. It is not in the Tuscarawas, according to Sterki (1907*a*, p. 390). In western Ohio and in southern and northwestern Indiana it is more widely distributed. Here it crosses over into the Lake Erie-drainage (Ohio Canal, Sterki), and into the lake (Sterki, and Walker, 1913). It occurs also in Beaver Creek, Lorain, Lorain Co., Ohio (Dall & Simpson, 1895), and in Michigan (Walker). It extends westwards and southwards to Minnesota, Iowa, Kansas, Oklahoma, northeastern Texas, and northern Louisiana. It also crosses over into the drainage of the Red River of the North (Winnipeg, Canada). There are no records from south of the Ohio, but the Carnegie Museum has it from the Tennessee in northern Alabama. From Alabama, there is only a single, doubtful and indefinite, previous record (Call).

Thus it seems that the center of this species is in the Mississippi and lower Ohio.

[36] This is the var. *contraryensis* of Utterback, a local phase.

Its absence in the Cumberland and upper Tennessee is remarkable, but probably accounted for by its ecological habits. On the Gulf plain, it is largely represented by other allied species.

Sterki says that the Lake Erie form is "little inflated and has few tubercles." This fits the specimen before me, but I cannot judge from a single example whether this is a constant difference.

Quadrula verrucosa (Rafinesque) (1820).

Tritogonia tuberculata (Barnes) Simpson, 1914, p. 318; *Tritogonia verrucosa* (Rafinesque) Vanatta, 1915, p. 554; *Quadrula verrucosa* (Rafinesque) Utterback, 1916, p. 62.

Plate IV, figs. 2, 3.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver River, Wampum, Lawrence Co.). Ortmann, 1909*b*, p. 198.

Characters of Shell: Shell large and heavy. Outline elongate-subtrapezoidal, considerably longer than high. Beaks low. Beak-sculpture consisting of one or two subconcentric bars, curving upwardly and nodular behind, followed by additional bars, which are more or less distinctly double-looped, and break up into nodules, which are indistinctly arranged in zig-zag waves. This sculpture is continued upon the disk. Shell moderately swollen or rather flat, with a distinct, but narrow posterior ridge. In front of the latter the sides of the shell are flattened or somewhat concave, thus forming a broad, shallow radial groove. The posterior nodular part of the beak-sculpture is continued upon the posterior ridge as a row of tubercles, which, however, are not very prominent, and gradually disappear. In front of the posterior ridge the disk, including the groove, is thickly studded with rather small, low tubercles, which are often more or less distinctly arranged in diagonal rows, and represent the continuation of the beak-sculpture. Toward the lower margin, these tubercles become irregular, and may disappear. Posterior slope with ribs radiating from the posterior ridge; they are small, irregular, and nodulous toward the beaks, but become larger toward the posterior end of the shell. Epidermis yellowish to rusty brown and blackish, without distinct rays, but generally suffused with green in irregular patches. Often the whole surface is greenish, and only the tubercles are more or less yellowish or brownish. Growth-rests more or less distinct. Old shells are generally uniformly dark brown or blackish.

Hinge-teeth well-developed, strong. Pseudocardinals divergent, large, ragged. Interdentum moderately developed. Lateral teeth long, straight, rather heavy.

Beak-cavity not very deep. Dorsal muscle-scars on the hinge-plate. Nacre white.[37]

In this species, we meet with a more or less distinct sexual difference in the shell, unusual in the subfamily *Unioninæ*. In the male the posterior margin of the shell is short and subtruncate, and the ribs of the posterior slope are generally well-developed and continued to the margin. In the female the posterior margin is broadened and flattened in the region of the posterior angle, and the ribs of the posterior slope are poorly developed and broadened, so that the posterior end of the shell appears expanded. This expansion corresponds to the location of the anal opening in the soft parts.

	L.	H.	D.
Size: 1. Edinburg, Cat. No. 61.3577 (sex doubtful)	156 mm.	86 mm.	43 mm.
2. Mahoningtown, Cat. No. 61.3574 (♂)	121 "	70 "	44 "
3. Pulaski, Cat. No. 61.4548 (♀)	130 "	64 "	37 "

No. 1 is the largest specimen from Pennsylvania, but larger ones are known from elsewhere. Scammon (1906) gives 168 as maximum length.

Soft parts (See Ortmann, 1912, p. 254). The *glochidia* have been figured by Surber (1912, Pl. 2, fig. 31). They are unusually small, 0.085 × 0.100 mm.

Breeding season: Sterki (1907*b*, p. 48) collected gravid females on June 10, 1907, and Surber gives April to June. I did not find any gravid females in Pennsylvania, but collected some on May 9, 1913, in Pocatalico River, and on May 23, 1912, in West Fork River, West Virginia. All these had eggs only, filling all four gills, forming lanceolate, not very solid, white placentæ. Those from Pocatalico River (two specimens) had the eggs brownish, discolored, and they were being discharged when opened (about two hours after capture). This was apparently premature discharge, and the eggs were dead (suffocated).

Remarks: This species has a very characteristic outline and sculpture. The latter, however, is quite variable. The tubercles of the disk may be larger or smaller, regular or irregular in size, rounded, subtriangular, or even vertically elongated. The ribs of the posterior slope are also variable, and more or less distinct. Toward the lower margin, the sculpture often disappears, and in some individuals the whole lower half of the shell may be smooth. The most remarkable fact in this species is the sexual differentiation of the shell, which has led Simpson to the opinion that it should represent a separate genus (*Tritogonia*). However, as I have shown, in all other characters, chiefly those of the soft parts, it is a true *Quadrula*. The posterior dilatation of the shell in the female is in an entirely different region from that in the females of the *Lampsilinæ*.

[37] In Pennsylvania, the nacre is always white; in the South (Alabama, etc.) it may be purple.

The sexual differences are sometimes quite striking, but not always so. It is by no means "one of the easiest species in which to distinguish the sexes," as Scammon (1906, p. 314) says. In the largest specimen, mentioned above, I am in fact in doubt whether it is a male or a female, and it is true that sometimes in large males (determined by the soft parts), the posterior end of the shell is somewhat expanded, with less developed ribs. But, as a rule, in individuals of medium and large size, the sex may be easily told from the shape of the shell. In young shells this is very hard, or even impossible to do.

It should be mentioned that the female shell is on the average more flattened and compressed than that of the male. This also is a rather unusual feature.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Industry, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Allegheny River, Kelly, Armstrong Co.

Locality in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Coraopolis, Allegheny Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Elk River, Sutton and Gassaway, Braxton Co., West Virginia.
New River, Hinton, Summers Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith); Elk River, Fayetteville, Lincoln Co., Tennessee (H. H. Smith); Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler); Paint Rock River, Trenton and Princeton, Jackson Co., Alabama (H. H. Smith); Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

West of Mississippi:

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Illinois River, Talequah, Cherokee Co., Oklahoma (F. B. Isely).
Bayou Pierre, De Soto Parish, Louisiana (L. S. Frierson).

Mississippi, Alabama, Georgia:

Pearl River, Mississippi (Juny collection).
Buttahatchee River, Hamilton, Marion Co., Alabama (H. H. Smith).
Sipsey River, Texas, Marion Co.; Fayette, Fayette Co.; and Elrod, Tuscaloosa Co., Alabama (H. H. Smith).
Forks of Black Warrior River, Walker Co., and Black Warrior River, Squaw Shoals, Jefferson Co., Alabama (H. H. Smith).
Valley Creek, Toadvine, Jefferson Co., Alabama (H. H. Smith).
North River, Haglers Mill, Tuscaloosa Co., Alabama (H. H. Smith).
Cub Creek, Pine Hill, Wilcox Co., Alabama (H. H. Smith).
Cahaba River, Gurnee, Shelby Co., Alabama (H. H. Smith).
Coosa River, Wetumpka, Elmore Co.; Weduska Shoals, Shelby Co.; Riverside, St. Clair Co., Alabama (H. H. Smith).
Choccolocco Creek, Calhoun Co., Alabama (H. H. Smith).
Oostanaula River, Rome, Floyd Co., Georgia (G. H. Clapp donor).
Conasauga River, Whitfield Co., Georgia (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 5): In Pennsylvania this species is rather local and not widely distributed. In the Ohio, Monongahela, and Allegheny, it is rather scarce, and only isolated specimens turn up. In the drainage of the Beaver it is a little more frequent, and the best places are at Edinburg and Pulaski. This would indicate, that the species prefers smaller rivers, which is substantiated by the fact that it is rather abundant in the headwaters of the Monongahela, in Dunkard Creek in Pennsylvania, and in West Fork River in West Virginia. In the upper Little Kanawha and in Elk River, West Virginia, it is also frequent.

This shell is found in coarse or fine gravel, generally not very deeply buried, but young shells are often found in fine sand and even in mud. In a mill-race of the Mahoning, at Edinburg, among heavy rocks, about a dozen were collected, all very large and ponderous. The best places are riffles with strong currents, interrupted by patches of *Dianthera americana*.

Scammon (1906, p. 314) reports this species in various ecological surroundings, but says it prefers gravel and shingle, with a swift current, while Call (1900, p. 465) says that it delights in muddy bottoms, which is surely not the case in Pennsylvania.

General distribution: Type locality, Ohio River (Rafinesque).

Simpson (1900) gives as the range of this species: "Mississippi-drainage generally; streams falling into the Gulf of Mexico from the Alabama system west to central Texas." This indicates a very wide distribution. In the Mississippi it goes into Wisconsin (Barnes, 1823; Lapham, 1860), and southern Minnesota (Grant, 1886; Holzinger, 1888), but its northward extension is generally rather restricted. Call (1895, p. 55) reports it from western New York, which is unconfirmed, and is very questionable, judging from its absence in the headwaters of the Allegheny in Pennsylvania, and its entire absence from the whole lake-drainage in Pennsylvania, Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a*) and Illinois (Baker, 1906). As our records show, it occurs in the tributaries of the Ohio in West Virginia and Kentucky, and goes up the Tennessee to northern Alabama, but is absent from the upper Tennessee region, except the Hiwassee River. Westward it goes to Iowa, Kansas, and Oklahoma, and its occurrence in Arkansas, and in the Gulf-drainage from Georgia to Texas is well established.

This species seems to belong more to the south and the west, but it has ascended the Mississippi to a considerable distance, and the Ohio practically throughout its whole drainage, except the smallest headwaters in the north and east.

It does not seem to be very abundant in the larger streams. I never found it in the Ohio proper below the Pennsylvania state-line, although it is in the Cincinnati list of shells.

Quadrula metanevra (Rafinesque) (1820).

Quadrula metanevra (Rafinesque) Simpson, 1914, p. 834.

Plate IV, figs. 4, 5, 6.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, p. 198.

Characters of the shell: Shell of medium size, heavy. Outline subtrapezoidal, subrhomboidal, or subquadrate, sometimes subtriangular, short, not longer, or very little longer, than high. Beaks moderately elevated. Beak-sculpture consisting of two or three subconcentric bars, which are angular and nodulous upon the posterior ridge; anterior part rather straight, and curved upward in front, thick, but not sharply marked. The nodulous portion is repeated upon the posterior ridge in the shape of tubercles, while the anterior part of the following bars becomes indistinct, and is soon supplanted by the sculpture of the disk. Occasionally the third and fourth bars show an indication of double-looped structure, and sometimes

even traces of a breaking up into small zig-zag nodes is seen. In certain other cases the beak-sculpture is separated from that of the disk by a smooth space. Shell sometimes rather flat, but generally more or less swollen, with a broad, distinct, and prominent posterior ridge. In front of the ridge, the shell is flat or depressed, but without forming a distinct radiating furrow. The posterior nodular part of the beak-sculpture is continued upon the ridge as large and distinct prominent tubercles or nodes, standing rather remote from each other; sometimes these nodes are broken up into clusters of nodules, and in rare cases they are rudimentary or absent. In front of the posterior ridge the shell is covered by larger or smaller nodules, very irregular and variable in arrangement, shape, and number. Sometimes there are very few, in other cases very many of them, but toward the lower margin they generally tend to disappear in larger shells, and the anterior part of the disk is always smooth. Towards the beaks, the nodules are smaller, and may disappear, or pass into the beak-sculpture. Posterior slope generally marked off from the posterior ridge by a narrow furrow, producing an emargination of the posterior margin, and its surface may be smooth, or tuberculated, or radiately ribbed. Epidermis yellowish to brownish black, with a characteristic greenish color-pattern: the rays are broken up into triangular spots of larger or smaller size, pointed toward the lower margin. These color-patches are very variable, sometimes almost absent, sometimes very distinct, chiefly so in young specimens; in older ones they become obliterated, the epidermis appearing uniformly brownish. Regular linear rays are sometimes present, but not often. Growth-lines more or less distinct.

Hinge-teeth well-developed, strong. Pseudocardinals divergent, large, ragged. Interdentum present, generally well-developed. Lateral teeth strong, of medium length. Beak-cavity deep or moderately deep. Dorsal muscle-scars on the hinge-plate. Nacre always white.

Sexes absolutely indistinguishable in the shell.

Size:	L.	H.	D.
1. Industry, Cat. No. 61.3866 (largest from Pennsylvania)	90 mm.	71 mm.	47 mm.
2. Kelly, Cat. No. 61.3861 (very flat)	89 "	70 "	36 "
3. Aladdin, Cat. No. 61.3868 (normal)	67 "	58 "	38 "

Soft parts (See Ortmann, 1912, p. 255, fig. 6). *Glochidia* figured by Lefevre & Curtis (1910, p. 97, fig. E, and 1912, p. 146, fig. E), by Surber (1912, Pl. 2, fig. 26), and Howard (1914, Pl. 5, fig. 31). Their measurements have been given as 0.18 × 0.19 mm. and 0.175 × 0.200 mm. I have not seen glochidia in Pennsylvania, but have found them in the flat form (var. *wardi*) from the Little Kanawha

River, West Virginia. The shape was the same, as reported, but they were slightly larger: 0.20 × 0.22 mm. I have repeatedly found specimens with eggs and with distinct placentæ; but when glochidia are present, the placentæ easily fall apart.

Breeding season: The specimen with glochidia was found on May 24, 1911, and a specimen with eggs was collected on June 22, 1909. Other specimens with eggs were received from Arkansas, collected on June 26, 1911. The early date for glochidia is remarkable. It is astonishing, on the other hand, that among numerous specimens collected on June 20, 21, and 22, 1911, in the Ohio River at St. Marys, West Virginia, no gravid females were found. The species surely is tachytictic; Surber (1912, p. 7) gives May to July as the breeding season.

Remarks: It is hardly possible to mistake this species on account of its marked shape and sculpture. Yet there is quite a range of variation, chiefly with regard to obesity of the shell, and to sculpture. As is seen in the measurements given above, some shells are considerably more flattened, and it is to be noted that such specimens are more frequent in the Allegheny than in the Ohio. This would express the same tendency toward flattening of the shell in smaller rivers, which we have noticed in several of the foregoing species. But in this case it is impossible to distinguish a flat race, since there are all intergrades, and only few flat individuals are found, always associated with others which are swollen (See Pl. IV, figs. 4, 5, 6).

In the development of the tubercles we notice an important variation in which the large tubercles of the posterior ridge are obliterated. Such specimens, which at the same time were rather flat, have been described by Lea (Obs. IX, 1863) as a separate species, *Unio wardi* (from Walhonding, Ohio; Wapsipinicon, Iowa; and Coal River, West Virginia).[38] Three specimens from the latter locality are in the Carnegie Museum, derived from the Hartman collection. They undoubtedly are the same specimens referred to by Lea, as being in the Hartman collection. They agree very well with Lea's figure, but the posterior ridge is not entirely smooth, although without the large tubercles. I have specimens like these from the Little Kanawha River and from the West Fork River. These also are remarkably flat. Finally specimens resembling these are sometimes found in western Pennsylvania (See Pl. IV, fig. 6). The second one, of which the measurements are given (from Kelly), should be by all means regarded as *wardi* and there is a half shell from the Monongahela at Charleroi, which has been labeled by Simpson as var. *wardi,* and rightly so. Compressed specimens, which also have the tubercles more or less obliterated, have been found occasionally all the way down from the

[38] Lea says: "Coal River, Logan Co., Va.," but Coal River and Little Coal River are today in Kanawha and Boone Cos., West Virginia.

Allegheny, Armstrong Co., Pennsylvania to Parkersburg, West Virginia, but in company with the normal form. They should be called *wardi*, but do not form a distinct race, but are rather individual variations.

It is interesting to note, that outside of our state, nearly all specimens from small rivers and creeks, such as West Fork River, the Little Kanawha, and Coal

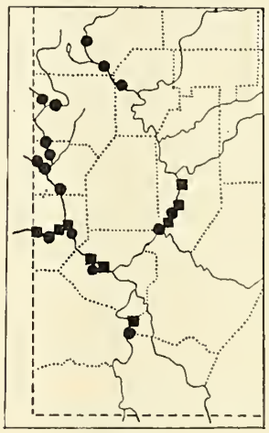


FIG. 6.

■ *Quadrula metanevra.*
● *Quadrula cylindrica.*

River, belong to this form called *wardi*, and it may be, that in such small streams, the *wardi*-type becomes the prevailing one, thus forming an ecological race. Sterki (1907*a*, p. 390) mentions such a case from Sugar Creek, a small tributary of the Tuscarawas River in Ohio.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Locality in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Beaver, Beaver Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork River, West Milford, Harrison Co., West Virginia (W. F. Graham).

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham), and Burnsville, Braxton Co., West Virginia.

Coal River and Little Coal River, Boone Co., West Virginia (Hartman collection).[39]

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Knoxville, Knox Co., Tennessee.

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Holston River, Mascot, Knox Co., Tennessee.

Mississippi-drainage and westward:

Peoria Lake, Illinois River, Illinois (Hartman collection).

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Black Rock River and Spring River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Spring River, Williford, Sharp Co., Arkansas (H. E. Wheeler).[40]

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Neosho River, Miami, Ottawa Co., Oklahoma (F. B. Isely).

Alabama-drainage:

Sipsey River, Texas, Marion Co., Alabama (H. H. Smith).

Coosa River, Wilsonville, Shelby Co., and Riverside, St. Clair Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 6): In Pennsylvania this species is restricted to the three large rivers, the Ohio, Allegheny, and Monongahela. In the Allegheny it goes up a little beyond the middle of Armstrong County. From the Monongahela it is known only from one locality, but it must have at one time ascended into West Virginia, for it occurs in the West Fork River.

Wherever found it is not rare, but it is most abundant in the Ohio below Pittsburgh. Here it favors the same places as most other species: coarse gravel in swiftly running water, and it helps to compose the shell-banks, where such are present (at Shippingport and Industry). This agrees with Scammon (1906, p. 350), who says that gravel-bars are its favorite habitat. In the Ohio below Wheeling it is frequently taken by the clam-diggers out of deep water in strong and steady currents.

General distribution: Type locality, Kentucky River (Rafinesque).

The general distribution, as given by Simpson (1900) is: "Mississippi-drainage area, except its southern portion, extending to the Tennessee and Arkansas River." This is quite correct, and it is to be particularly noted, that toward the east and north, this species does not cross over into any other drainage-system. As we have seen, in western Pennsylvania it does not advance far up into small streams,

[39] See above p. 49. Specimens from West Fork, Little Kanawha, and Coal Rivers all (together six) represent the form *wardi*.

[40] This specimen is a good representative of the var. *wardi*.

and the same seems to be true elsewhere, although there are a few exceptions, and it seems that in such cases the main form tends to be replaced by the variety *wardi*.

In Ohio the main species hardly occurs outside of the Ohio proper (Sterki, 1907*a*). In Indiana it is known only from the larger rivers, the Ohio, White, Wabash, and Kankakee, and also from Eel, Blue, and Whitewater Rivers (Call, 1896 and 1900). In Illinois the same rule seems to prevail, so that its range covers the greater part of the state, except the northern and northeastern extremity (Baker, 1906; Wilson & Clark, 1912*a*). In the Mississippi-drainage, this species goes up into the Wisconsin River in Wisconsin, and the Minnesota River in Minnesota.

Westwards it is found as far as southeastern Kansas (Scammon, 1906) and to the southwest it extends to Oklahoma and the Ouachita River in Arkansas (Call, 1895; Wheeler, 1918, and our own material). The records from Louisiana and Texas are doubtful.

South of the Ohio in West Virginia this species is found in the headwaters of the Monongahela (West Fork River), in the Little Kanawha, and in Coal River, but, according to specimens in the Carnegie Museum, in the form *wardi*. Records from Kentucky and Tennessee are scanty. The type-locality is the Kentucky River. It is known from the Cumberland River (Scammon, 1906, and Wilson & Clark, 1914) and our material shows its presence in the Tennessee up to the lower Holston (See also Lewis, 1871). It turns up again in the Alabama system (Lewis, 1877, Call, 1885, Carnegie Museum). Lea's locality (Obs. 10, 1863, p. 430), Columbus, Lowndes Co., Mississippi, belongs with this group of stations.

This latter set of localities is interesting, in view of Simpson's statement, that it is missing in the lower Mississippi region. If this is correct, it could have reached the Alabama-drainage only by crossing over from the Tennessee-drainage. This case should be kept in mind, for it is of zoögeographical importance.

Quadrula cylindrica (Say) (1817).[41]

Quadrula cylindrica (Say) Simpson, 1914, p. 832.

Plate V, figs. 1, 2, 3.

Records from Pennsylvania:

Harn, 1891, p. 136 (western Pennsylvania).

Rhoads, 1899, p. 136 (Ohio River, Coraopolis, Allegheny Co.; Beaver, Beaver Co.; and Beaver River, Wampum, Lawrence Co.).

Ortmann, 1909*b*, p. 198.

Characters of the shell: Shell rather large, heavy. Outline elongated sub-

[41] Not 1816 (See footnote 20 under *Amblema plicata*, p. 25).

trapezoidal, or almost rectangular, considerably longer than high. Beaks moderately prominent. Beak-sculpture consisting of a number of bars, the first of which seems to be simple, the following two or three distinctly double-looped, with the posterior loop angular and nodose upon the posterior ridge. Farther on, upon the disk, the nodes of the posterior loop are continued as strong tubercles, while the anterior loop breaks up into small granules, which generally assume a zigzag arrangement. They are continued downward to a variable extent, but generally they soon disappear. Shell greatly swollen, from almost subcylindrical to rather flat, with a broad and distinct posterior ridge. In front of the ridge the shell is flattened, but has no radial furrow; behind the ridge the shell is more or less depressed, thus generally producing a slight emargination of the posterior margin. Upon the posterior ridge stands a row of tubercles (continuing the beak-sculpture), which increase in size toward the posterior angle, and may be larger or smaller; in some cases they are more or less obliterated. In front of the posterior ridge the shell is generally smooth, but towards the beaks we find a number of small tubercles or nodules, described above as a continuation of the broken-up anterior loops of the beak-sculpture. The development of these nodules is quite variable. The posterior slope may be ornamented with ridges or radiating rows of nodules, or may be entirely smooth. Epidermis yellowish to brownish or greenish, with dark green rays broken up into a characteristic pattern of triangular spots, pointed toward the lower margin. The distribution and size of these spots is rather irregular and variable, but they are generally well-developed and distinct, and only in rare cases do they become obliterated. Linear rays are, as a rule, entirely absent, indications of them are seldom seen upon the posterior ridge or posterior slope.

Hinge-teeth well-developed, but not very heavy. Pseudocardinals divergent, ragged. Interdentum narrow or almost absent. Lateral teeth long. Beak-cavity moderately deep. Dorsal muscle-scars on the hinge-plate. Nacre always white.

Sexes absolutely indistinguishable in the shell.

	L.	H.	D.
Size: 1. Utica, Cat. No. 61.3852 (without any nodes)	123 mm.	50 mm.	45 mm.
2. Meadville, Cat. No. 61.3850 (without any nodes)	119 "	54 "	36 "
3. Godfrey, Cat. No. 61.4358 (with strong nodes)	83 "	33 "	33 "
4. Aladdin, Cat. No. 61.3856 (with strong nodes)	84 "	37 "	30 "

Pennsylvanian specimens compare favorably with previous measurements; in fact, the size of the first one given represents the maximum on record.

Soft parts (See Ortmann, 1912, p. 256). It is to be added that gravid females

have been observed subsequently. All four gills are used as marsupia. The eggs form placentæ of lanceolate shape, of a peculiar yellow-brown or pale orange color. *Glochidia* have been observed in specimens from Holston River in Tennessee. Their shape is subcircular; length and height about 0.19 mm. Thus they resemble those of *Q. metanevra* (0.18 × 0.19), but they are more nearly circular.

Breeding season: Gravid females were found on May 22, 1914; May 23, 1914; May 24, 1911; May 25, 1914; July 8, 1913. Glochidia were observed on May 23. The species apparently is bradytictic, as usual in the genus, but the date for glochidia is rather early. Wilson & Clark (1914) found gravid specimens in the Cumberland in June and July.

Remarks: This is an eminently characteristic species. The chief variations observed concern the general shape of the shell and the sculpture. The typical shape is "subcylindrical," with the height about the same, or nearly the same, as the diameter (see measurements of Nos. 1 and 3, above), but there are rather flat individuals. Sterki (1907*a*, p. 390) calls attention to a form from the Tuscarawas River, which lacks the tubercles of the posterior ridge. This form is the prevailing one in western Pennsylvania, and is most abundant in the Beaver drainage and in French Creek. I have many specimens in which no trace of the tubercles is seen, and generally also the smaller nodules of the anterior part of the shell near the beaks and the sculpture of the posterior slope are absent in them, so that the shell appears absolutely smooth. Yet there are all sorts of intergrades, connecting this smooth with the normal form (See Pl. V, figs. 2, 3). Farther down in the Ohio this smooth form is not found. These conditions are to a degree parallel with those observed in *Q. metanevra* and its var. *wardi*.

Very often the degree of obesity of the shell is correlated with the development of the sculpture, so that smooth specimens are at the same time unusually compressed. But this is not always the case, and smooth individuals may be subcylindrical, as our No. 1 (See measurements) and sculptured individuals may be somewhat compressed (See No. 4).

This smooth, and sometimes compressed form of the headwaters is so far known only from the Tuscarawas River in Ohio, from Beaver River and French Creek, in Pennsylvania, and from the upper Monongahela (West Fork River) in West Virginia.

It should be mentioned in this connection that a similar, compressed form is known from the headwaters of the Clinch River, in Virginia. This is the var. *strigillata* (Wright), but it is not a smooth form. On the contrary it is covered by a multitude of small tubercles. But here also the large tubercles of the posterior ridge are absent.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville and Shenango, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Aladdin, Godfrey, Johnetta, and Kelly, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton and Meadville, Crawford Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Localities in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Beaver, Beaver Co., and Coraopolis, Allegheny Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Parkersburg, Wood Co., West Virginia; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).[42]
West Fork River, West Milford, Harrison Co., W. Va. (W. F. Graham).[43]
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham), and Burnsville, Braxton Co., West Virginia.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Trenton, and Princeton, Jackson Co., Alabama (H. H. Smith).
Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Noeton, Grainger Co.; Austin Mill and Church Hill, Hawkins Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee.
Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.
Clinch River, Edgemoor and Clinton, Anderson Co.; Clinch River Station, Claiborne Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia.[44]
Powell River, Combs, Claiborne Co., Tennessee.

West of the Mississippi:

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Neosho River, near state line, Kansas (R. L. Moodie); Miami, Ottawa Co., Oklahoma (F. B. Isely).

[42] Ten specimens are at hand, but only two or three approach the smooth form, and none is entirely smooth.

[43] An entirely smooth specimen.

[44] In the upper North Fork of the Holston and the upper Clinch River in Virginia, the var. *strigillata* gradually replaces the normal form.

Distribution and Ecology in Pennsylvania (See fig. 6): This species has been found both in the larger rivers and in some of the smaller creeks, but according to my experience, it is distinctly more frequent in the latter. Yet it does not go up into the extreme headwaters. It is not rare in the Beaver-drainage, and also in French Creek, but entirely absent in the upper Allegheny. At all other localities, it is distinctly a rare shell, and the same is true for the Ohio below our state.

Whenever I found this species alive, it was in swiftly running water, upon bars of gravel, very often in riffles with an abundant growth of *Dianthera americana*. In fact, on the edge of such patches, I was most successful in taking this species alive. It is mostly not deeply buried, often simply lying upon the bottom. In the Ohio, it is upon the shell-banks, which become accessible only at the lowest stage of the river. This agrees with Scammon (1906), who observed that the "favorite habitat is bars of gravel or shingle in rather swift current."

General distribution: Type locality, Wabash River (Say).

Simpson (1900) gives for this species: "Entire Ohio, Cumberland, and Tennessee river systems; west to Nebraska (doubtful); south to Arkansas and Indian Territory." The first three rivers undoubtedly are the metropolis of this species, and here it is found from western Pennsylvania[45] through Ohio and West Virginia to Tennessee and northern Alabama (Tennessee-drainage). It is also frequent in the part of Indiana drained by the Ohio, White, Wabash,[46] and Kankakee Rivers (Call, 1896*a* and 1900), but in Illinois it is found only in the southern part (Ohio and Wabash, Baker, 1906). Thence, in a northerly and northwesterly direction, it is not found any more (this fact should be noted), but it is present farther South in the Mississippi-drainage, in southern Missouri (Utterback, 1916), in southeastern Kansas, eastern Oklahoma, and in Arkansas. Call (1895, p. 15) reports this species from the Alabama River, Selma, Dallas Co., Alabama. This is the only locality outside the Mississippi area, and seems to be erroneous, for it has never been found again in this system.

Genus Rotundaria Rafinesque (1820).

Ortmann, 1912, p. 257; Simpson, 1914, p. 903 (as subgenus of *Quadrula*).

Type *Obliquaria tuberculata* Rafinesque.

Two species have been assigned to this genus, which may be only varieties of the same species. Only one of them is found in Pennsylvania.

[45] Call (1895) quotes western New York, but this record has never been substantiated. It is missing in Marshall's list (1895).

[46] According to Goodrich (1914), *Q. cylindrica* recently has crossed over into the Maumee River, and descended as far as Antwerp, Paulding Co., Ohio. He calls it by the varietal name *strigillata*, but probably this is an error.

ROTUNDARIA TUBERCULATA (Rafinesque) (1820).

Quadrula (*Rotundaria*) *tuberculata* (RAFINESQUE) SIMPSON, 1914, p. 903.

Plate V, fig. 4.

Records from Pennsylvania:

Marshall, 1895 (Allegheny River, Warren Co.).

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).

Ortmann, 1909*b*, p. 201.

Characters of the shell: Shell rather large and heavy. Outline subrotund, or ovate, or subquadrate, subtruncate, and sometimes slightly emarginate behind, not very oblique, height and length not very different. Beaks moderately prominent, inclined forward. Beak-sculpture consisting of numerous, fine, irregular, broken, or wavy ridges, showing more or less distinctly a zig-zag arrangement, with a posterior triangular loop most distinct, while anteriorly this arrangement is irregular. The first two or three bars are concentric, then follow three or four which are only double-looped, and then other bars (even as many as ten or more), which exhibit the iregular zig-zag sculpture. The beak-sculpture is continued well upon the disc, and is immediately followed by the nodules of the latter. Shell rather compressed, or only slightly swollen, disk gently convex, with an indistinct, posterior ridge, which may be altogether absent. Posterior slope flat or somewhat depressed, often with a more or less distinct wing-like expansion and elevated posterior upper margin (chiefly in young specimens). Surface of shell covered with tubercles or nodules, which, however, always leave free the anterior portion (one-fourth to almost one-half) of the shell. Tubercles very variable in number, size, arrangement, and shape; they may be rather few, or quite numerous, are always quite irregular in size, and show no definite arrangement. Generally they are a little transverse, at least some of them. In the center of the shell the tubercles are generally most numerous, and upon the posterior slope and the wing, they often assume the shape of radiating, nodulous ribs. In old shells the tubercles disappear toward the lower margin, and in very large specimens the whole lower half of the shell (or even more) may be without tubercles.

Epidermis brown, lighter or darker, uniform in color, only in very rare cases mere traces of broad greenish rays are barely indicated. Growth-rests slightly darker, or not marked.

Hinge-teeth strongly developed and very heavy. Pseudocardinals large, ragged, divergent. Very often there are one or even two subsidiary pseudocardinals in the right valve (one in front, the other behind the normal tooth).

Interdentum well-developed and extremely wide. Lateral teeth short and strong. Beak-cavity very deep, compressed. Dorsal muscle-scars on the hinge-plate. Nacre of a peculiar and characteristic brownish purple color, lighter or darker, sometimes shading to whitish toward the beak-cavity, and coppery-brownish, iridescent posteriorly.

Sexes absolutely indistinguishable in the shell.

	L.	H.	D.
Size: 1. Godfrey, Cat. No. 61.4411	108 mm.	96 mm.	47 mm.
2. Neville Island, Cat. No. 61.1637	77 "	73 "	41 "
3. Utica, Cat. No. 61.3947	58 "	55 "	36 "

Soft parts (See Ortmann, 1912, p. 258, fig. 7). Gravid females have been found subsequently. Only the outer gills are charged, the placentæ are subcylindrical and white. *Glochidia* described and figured by Utterback (1916, Pl. I, fig. 4). They are unusually large, 0.267 × 0.325 mm. Surber (1912, Pl. 2, fig. 19) figures the glochidia of the closely allied *R. granifera* (Lea). These also are remarkable for their size, 0.29 × 0.355 mm., but I have found them in *R. granifera* from Black River, Arkansas, to be considerably smaller, 0.25 × 0.28 mm.

Breeding season: I found my gravid females on May 22, 1914; May 25, 1915; July 5, 1913; July 7, 1913; July 13, 1913. Utterback's glochidia were found on August 11.

Remarks: Although this species resembles in shape and sculpture several other species, chiefly *Quadrula pustulosa* and *Plethobasus cooperianus*, it is always easily recognized by the peculiar color of the nacre and the extremely broad interdentum. I have old specimens, which are so much corroded at the beaks, that the whole section bearing tubercles is gone, and only the smooth lower half of the shell remains intact, yet the interior of the shell characterizes them. All Pennsylvanian specimens are rather flat, but farther down the Ohio occasional specimens are met with which are somewhat more swollen. A specimen from Portsmouth, Ohio, has distinctly more prominent and more incurved beaks, and might fall under *R. granifera* (Lea): but the other characters of the latter, as given by Simpson (1900, p. 795, footnote 2) are absent.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Cooks Ferry and Industry, Beaver Co.; Neville Island, Allegheny Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Slipperyrock Creek, Wurtemberg, Lawrence Co.
Allegheny River, Godfrey, Johnetta, and Kelly, Armstrong Co.; Walnut Bend, Venango Co.
French Creek, Utica, Venango Co.
Dunkard Creek, Wiley, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Localities in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Beaver, Beaver Co.; Coraopolis, Allegheny Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Ohio-drainage:

Ohio River, St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork River, Lynch Mines, Harrison Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

Elk River, Shelton, Clay Co., West Virginia.

New River, Hinton, Summers Co., West Virginia.

Tennessee-drainage:

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).

Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).

Flint River, Gurley, Madison Co., Alabama (H. E. Wheeler).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Concord and Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Noeton, Grainger Co.; Austin Mill and Church Hill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Sullivan Co., Tennessee.

North Fork Holston, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry, Scott Co., Virginia.

West of the Mississippi:

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Hollister, Taney Co., Missouri (W. I. Utterback); Rogers, Benton Co., Arkansas (R. L. Moodie); Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Distribution and Ecology in Pennsylvania (See fig. 7): In Pennsylvania, this species has a rather wide distribution, being found in all three river-systems. It goes rather high up (in the Allegheny as far up as Warren Co., according to Marshall, 1895). The smallest streams in which I have found it are Slipperyrock, French, and Dunkard Creeks. From the Monongahela proper records are missing, but it ascends to West Virginia (West Fork River). It is nowhere abundant, and is decidedly one of the rarer shells, only few individuals having been found at any one place. This also holds good for the Ohio below Pittsburgh, where this species is by no means abundant.

It is hard to say what the ecological preferences are, but the specimens I collected alive always came from riffles with rather coarse gravel and a rapid flow of water. In the Ohio proper it inhabits the shell-banks. However, Baker (1898*a*, p. 36) says that it is found in the Chicago area in the larger lakes and rivers on a muddy bottom.

General distribution: Type locality, Ohio River (Rafinesque).

The range of this species according to Simpson (1900), is "Mississippi-drainage generally; southern Michigan; San Saba Co., central Texas." Call (1885) says: "New River, Virginia, to Tuscumbia, Alabama; to Iowa; to Michigan."

The area occupied by this species includes the Tennessee, Cumberland, and Ohio drainages; toward the west and southwest, it apparently becomes scarce. It has not been reported from Kansas (Scammon, 1906), but is present in southern Missouri and northwestern Arkansas.[47] Simpson's record from Texas is the

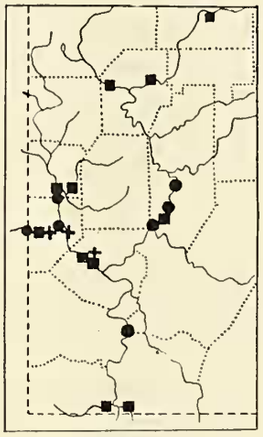


Fig. 7.

■ *Rotundaria tuberculata.*
+ *Plethobasus cooperianus.*
● *Plethobasus cyphyus.*

only one in this state, and the list of Singley (1893) does not contain it. Also in a northwesterly direction, the distribution seems to be limited, and barely reaches to Iowa in the Mississippi. Northwards it extends all over Illinois, to southern Cook Co. (Baker, 1898*a*, 1906) and goes in the Mississippi, Rock, Wisconsin, and St. Croix Rivers, to Wisconsin (Barnes, 1823; Lapham, 1860; Cooper, 1855). In Indiana it has been recorded by Call (1896*a*) from the Ohio, Wabash, and White

[47] Call (1895) does not mention this species from Arkansas, but, aside from the localities represented in the Carnegie Museum, it occurs also in the Big Buffalo Fork of White River (Meek & Clark, 1912) and W. I. Utterback (1916) reports it from southern Missouri.

Rivers, and in Ohio by Sterki (1907*a*) from the Ohio, Little Miami, and Tuscarawas Rivers. In addition, it is found in southern Michigan (Walker, 1898), and in Lake Erie (Barnes, 1823; Walker, 1913). Here we have apparently the only region, where this species leaves the Mississippi-drainage, and it is quite clear, that this was done by the Wabash-Maumee route. On the Pennsylvanian shores of Lake Erie it has not as yet been found.

Genus Plethobasus Simpson (1900).

Ortmann, 1912, p. 259; Simpson, 1914, p. 805 (as section of *Pleurobema*).

Type *Obliquaria cyphya* Rafinesque.

Three species are known to belong to this genus, of which only two are found in Pennsylvania. But since the third turns up in the Ohio, not far from the western state-line, I give here a key for all three of them.

Key to the species of Plethobasus.

a_1. Shell rounded, ovate, or oblique, without a radial depression running toward the posterior basal margin.

b_1. Shell subrotund, or subovate, only slightly oblique. Disk with scattered, irregularly disposed, rounded, or slightly transverse nodules, leaving free the anterior part of the shell, but generally extending more or less upon the posterior slope. . . . . *P. cooperianus.*

b_2. Shell subovate, very strongly oblique. Disk with more or less transverse tubercles, or subconcentric, more or less interrupted ridges, restricted to the middle of the shell, leaving the anterior part as well as the posterior slope free of sculpture. . . . . *P. cicatricosus* (extralimital).

a_2. Shell obliquely elongated, with a broad and shallow radial depression running toward the postbasal margin. In front of the depression a radiating row of low and broad, often transverse, tubercles; sometimes also a few indistinct tubercles behind the depression. . . . . *P. cyphyus.*

Remarks as to nomenclature and synonymy: Frierson (1911) has published a paper dealing with these forms, but in my opinion he starts from an incorrect assumption. This assumption is, that *U. cicatricosus* Say (1829) is the same as *U. œsopus* Green (1827) (which in turn is identical with *cyphyus* Rafinesque, 1820). The original description of Say mentions two important characters: tubercles and anterior position of beaks (great obliquity), which do not leave the slightest doubt, that the species was correctly understood by subsequent writers (*U. cicatricosus* Reeve, 1864, Pl. 8, fig. 31, and Simpson, 1900).

Reeve figures (*Cf.* Pl. 13, fig. 50) a smaller and less elongated individual. Frierson believes that this is another species. If that were the case, I would be compelled to make three or four additional species out of my (scanty) material of *cicatricosus*.

There appears to me to be no ground for Frierson's introduction of the new

specific name of *detectus* (*l. c.*, p. 52, Pl. 2, lower fig.; Pl. 3, upper fig.). This is a synonym of *cicatricosus*.

I think that Frierson makes another mistake in identifying Lea's *U. varicosus* (Obs. I, 1834, Pl. 11, fig. 20) with his *detectus*. Lea's species is very doubtful, and the figure is possibly inaccurate in several respects; but chiefly in that the sculpture is entirely different from that of the species of *Plethobasus* (continuous, concentric, rather regular ridges, not confined to the middle of the shell). I have shown above that Lea's species is, if anything, an exceptional individual of *Fusconaia subrotunda* (Lea) (See above, p. 9).

Frierson's *U. cicatricoides* (p. 53, Pl. 2, upper fig.) is also only an extreme variation of *cicatricosus*, distinguished by less oblique shell, and less anterior beaks. It connects this species with *cooperianus*. I have a specimen (St. Marys, West Virginia), which answers well to Frierson's figure. A specimen from the same locality is more distinctly oblique, and stands actually midway between the two figures on Frierson's Pl. 2, and comes very close to Call's figure of *U. varicosus* (1900, Pl. 55) except that it is not so much drawn out at the lower posterior end. And further certain individuals of *P. cooperianus*, collected by myself, very closely approach in outline the first one, just mentioned, but the sculpture is more distinctly and typically that of *cooperianus*.

Finally these intergrading forms also show certain relationships to *P. cyphyus*, which will be discussed below.

Plethobasus cooperianus (Lea) (1834).

Quadrula cooperiana (Lea) Simpson, 1914, p. 852.

Plate V, fig. 5.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Beaver, Beaver Co.; and Coraopolis, Allegheny Co.).
Ortmann, 1909*b*, p. 198.

Characters of the shell: Shell moderately large, heavy. Outline subrotund, subovate, or subtriangular, about as long as high, slightly oblique. Beaks moderately high, more or less inclined forward, but not at the anterior end of the shell. Beak-sculpture not observed, but probably poorly developed, and not extending to any considerable degree upon the disk, since the latter is always smooth near the beaks before the tubercles begin. Shell moderately swollen, rather evenly convex upon the sides, without a posterior ridge. Posterior slope very slightly compressed, in young specimens sometimes with an indication of a wing. Disk covered with nodes or tubercles, which, however, always leave free the anterior

part of the shell, and may be scarce or nearly absent upon the posterior slope. Tubercles variable in size, shape, and arrangement. There is no definite arrangement, except sometimes a concentric one, parallel to the growth-lines. The shape of the tubercles may be rounded or tear-like, but generally there are at least some, which are peculiarly compressed and transversely elongated (appearing as "pinched up"). The transverse dilatation of the tubercles is not very great. The tubercles may be rather crowded and numerous, or they may be scarce, sometimes only a few are developed, and they often disappear entirely toward the lower margin. Posteriorly, upon the posterior slope, the tubercles may be missing, or a few, or they may be as numerous as in the middle of the shell, or may even assume the shape of nodular, radiating ribs.

Epidermis yellowish brown to rusty or chestnut-brown, rather dark, when old. Very often the posterior slope is lighter than the rest, yellowish or olive-brown. Growth-rests darker. Greenish, indistinct rays are very rarely indicated and only in young specimens.

Hinge-teeth well-developed. Pseudocardinals divergent, ragged. Interdentum moderately wide. Lateral teeth moderately long, strong. Beak-cavity moderately deep. Dorsal muscle-scars on the hinge-plate. Nacre whitish, often suffused with a delicate pink inside of the mantle-line, most intense toward the hinge-teeth. Very rarely the whole interior is pink.

No sexual difference whatever in the shells. Call's remarks (1900, p. 485) about the differences of the males and females do not at all hold good.

	L.	H.	D.
Size: 1. Industry, Cat. No. 61.3882	90 mm.	78 mm.	46 mm.
2. Shippingport, Cat. No. 61.3881	69 "	61 "	38 "
3. St. Marys, Cat. No. 61.4595	69 "	71 "	41 "

Soft parts (See Ortmann, 1912, p. 361). *Breeding season:* Gravid females and *glochidia* have not yet been observed. On June 20 to 22, 1911, I obtained a good number (about fifty) specimens in the Ohio at St. Marys; additional ones were found on July 13, 1911, at Portland. All had the characteristic light orange color of the soft parts. Of about two dozen females none was gravid, and every one had only the outer gills marsupial. The sexual glands were grayish or brown and in many cases distinctly pinkish. Thus it is probable, that the eggs also are pink, as in *P. cyphyus*.

Remarks: Externally in shape and sculpture this species greatly resembles *Quadrula pustulosa* (Lea) and *Rotundaria tuberculata* (Rafinesque). In the tubercles the resemblance to the latter species is so great that there might be a close genetic

relationship between the two. However, in the beak-sculpture, in the hinge, the color of the nacre, and chiefly in the soft parts, there are important differences, amounting to generic distinctness. The color of the soft parts of *P. cooperianus* is also rather unique (pale orange, found also in the other species of the genus). *Q. pustulosa* is, of course, distinguished by the soft parts; but there are also differences in the shell. It is generally smaller, the tubercles are not of the peculiar transverse shape, and the outline of the shell is not so oblique. The color of the epidermis and the presence of broad rays near the beaks also distinguish *Q. pustulosa*.

P. cooperianus is very variable in outline. There are specimens, which are almost round, but generally they are drawn out at the lower posterior end, so as to render the outline ovate and oblique, and in some cases even subtriangular. The beaks are always inclined forwards, but they never are at the most anterior end of the shell. Very oblique specimens approach *P. cicatricosus* (Say), and individuals corresponding to *cicatricoides* of Frierson (see above), may be regarded to a certain degree as intergrades between the two. In sculpture this species also intergrades in the direction of *cicatricosus*, if the tubercles are more or less restricted to the middle of the shell. However, although there are certain individuals, which are intermediate in the one or the other character, there is no complete series of intergrades, and all my specimens may be assigned to the one or the other species.

Specimens from the Cumberland and Tennessee drainages have the sculpture generally better developed than specimens from the Ohio River.

Localities represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co., Pennsylvania; Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Marietta, Washington Co., Ohio (V. Sterki); Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.

Cumberland River, Cloyds Landing, Cumberland Co., Kentucky (B. Walker donor).

Tennessee River, Knoxville, and Brabsons Ferry, Knox Co., Tennessee.

Clinch River, Edgemoor, Anderson Co., Tennessee.

Distribution and Ecology in Pennsylvania (See fig. 7): This is one of the rarest species in Pennsylvania, and exists only in the Ohio River in Beaver and Allegheny Cos., and is even there very scarce. I was able to secure only four specimens, one of which was alive. The latter was found upon a shell-bank, in a steady current, associated with the usual bank-forming species.

Farther down the Ohio, *P. cooperianus* becomes more abundant, and it is quite common in the region of St. Marys and Marietta, where it is frequently taken

by the clam-diggers out of deep water, with the other bank-forms. This seems to be its favorite habitat.

General distribution: Type-locality, Ohio River (Lea).

This species seems to be restricted to the Ohio, Cumberland, and Tennessee systems, and the known records are all from these rivers and some of their larger tributaries, as for instance the Clinch in eastern Tennessee, the Wabash in Illinois and Indiana, and possibly also the Illinois River (Fulton Co.) in Illinois (Baker, 1906). It has been reported also from the Mississippi in Iowa,[48] but this is doubted by Simpson. It is to be especially noted, that from Indiana through Ohio and West Virginia to Pennsylvania, this species is restricted to the Ohio proper.

Plethobasus cyphyus (Rafinesque) (1820).

Pleurobema æsopus (Green) Simpson, 1914, p. 806; *Pleurobema cyphia* (Rafinesque) Vanatta, 1915, p. 556.

Plate V, fig. 6; Plate VI, figs. 1, 2, 3.

Records from Pennsylvania:

Green, 1827 (rivers near Pittsburgh).
Harn, 1891 (western Pennsylvania).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.; and Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 198.

Characters of shell: Shell rather large, heavy. Outline elongated-subovate, generally (except in young shells) distinctly longer than high, somewhat oblique, with the beaks not very high, inclined forward, but not at the anterior end of the shell. Beak-sculpture consisting of a few, thick, concentric ridges, not extending upon the disk. Shell moderately swollen, but old shells sometimes more considerably so; sides convex, with a broad and shallow radial depression, running from the beaks toward the posterior lower margin, producing a more or less distinct shallow excavation of the margin. In front of this depression, a radial row of low, transverse tubercles running from the beaks to the lower margin. These tubercles begin at a certain distance from the beaks, are more or less distinct (sometimes almost obsolete), and are somewhat irregular, larger or smaller. In rare cases they are cut by obscure, nearly vertical, lines (similar to *P. cicatricosus*). Behind the radial depression there is a low and broad ridge, passing gradually into the posterior slope. This part of the shell is generally less swollen than the anterior, and may be entirely smooth, or may show irregular, low rugosities, and sometimes

[48] Call (1885) and Keyes (1888) give Muscatine, Iowa, and Pratt (1876) Davenport, Iowa, but it is not in Witter's (1878) list from Muscatine.

there are individuals with indications of another row of tubercles upon the posterior ridge, which is, however, always less distinct than the anterior row.

Epidermis yellow to dark brown. In young specimens, the color is generally a rather light yellow (wax-yellow), becoming russet or chestnut-brown in older ones. There is no trace of rays. Growth-rests darker than the rest of the surface, but not sharply marked.

Hinge-teeth well-developed. Pseudocardinals moderately large, divergent, ragged. Interdentum moderately wide or narrow. Lateral teeth rather long. Beak-cavity not very deep. Dorsal muscle-scars on the hinge-plate close to the beak-cavity. Nacre white.

There is not the slightest sexual difference in the shell, and neither the length nor the obesity is connected with the sex.

	L.	H.	D.
Size: 1. Kelly, Cat. No. 61.3817	122 mm.	81 mm.	50 mm.
2. Kelly, Cat. No. 61.4598 (long ♂)	108 "	74 "	47 "
3. Kelly, Cat. No. 61.5566 (long ♀, gravid)	93 "	64 "	43 "
4. Kelly, Cat. No. 61.3817 (short ♀, gravid)	90 "	67 "	42 "
5. Godfrey, Cat. No. 61.4599 (short ♂)	88 "	72 "	45 "
6. Shippingport, Cat. No. 61.4600 (long ♂)	78 "	58 "	36 "

Soft parts (See Ortmann, 1912, p. 260, fig. 8). *Glochidia* (See Ortmann, *ibid.*). It should be remarked that the measurements previously given were taken from immature glochidia. Gravid females collected subsequently contained fully developed larvæ, and according to these, the glochidia measure 0.21 × 0.20 mm. Surber (1912, Pl. 1, fig. 12) illustrates them, and gives the size as 0.22 × 0.20 mm.

Breeding season: I have found gravid females on the following dates: June 20, 1911; June 21, 1911; June 22, 1909; July 3, 1908; July 4, 1911; July 13, 1908; July 13, 1911; July 25, 1910; July 27, 1910. Glochidia were observed on July 4 and July 25. Thus this species appears to be typically tachytictic, breeding in June and July. Probably the season begins in May, as stated by Surber.

Remarks: This is a well-marked species, at least in Pennsylvania, characterized by the shape of the shell, sculpture, and color of the epidermis and soft parts. The most closely allied species is *P. cicatricosus*, a form not found in Pennsylvania, but farther down the Ohio (nearest point St. Marys, West Virginia). *P. cyphyus* is distinguished from this species by the more elongated, less oblique shape, with the beaks less anterior, by the sculpture, and the presence of an oblique furrow upon the disk. However, there are individuals, which form, to a degree, a transition between these two species. To these transitional forms belongs *U. cicatricoides* of Frierson (See above, p. 62), but, on account of the absence of a radiating furrow,

the latter should be classed rather with *P. cicatricosus*. One of my specimens from St. Marys agrees rather well with *U. cicatricoides*, but it has upon the disk a slight indication of a depression, since the tubercles are cut off rather suddenly behind, making the posterior part of the shell appear contracted; but the broad furrow of *P. cyphyus* is not by any means developed.

In sculpture, *P. cyphyus* represents a further reduction of the tubercles of *P. cicatricosus*. They are rather poorly developed, but still show in most cases the character of short, transverse ridges. Sometimes these tubercles have almost entirely disappeared. Where they are better developed, in rare cases even the vertical dividing lines of the ridges, seen so frequently in *P. cicatricosus*, are indicated.

Young specimens of *P. cyphyus* somewhat resemble in shape *Truncilla rangiana* (Lea). But the latter species has a more greenish olive epidermis, with more or less distinct rays.

There is considerable variation in the comparative length of the shell of *P. cyphyus*. A short appearance is given to the shell by a smaller development of the posterior slope, and such shells are decidedly more abundant among young individuals. Old specimens are, as a rule, greatly elongated, and in these it often happens that the radial furrow becomes effaced. If such specimens have at the same time poorly developed tubercles, they resemble in shape old specimens of *Fusconaia subrotunda*, but they generally differ in the color of the epidermis, lighter hinge, and chiefly in the color of the soft parts (light orange). Of course, if females are at hand, no mistake is possible.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Shippingport and Industry, Beaver Co.; Coraopolis, Allegheny Co. (S. N. Rhoads).
Monongahela River, Westmoreland Co. (G. A. Ehrmann).
Allegheny River, Aladdin, Godfrey, Kelly, and Templeton, Armstrong Co.

Locality in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

Beaver River, Wampum, Lawrence Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, McMillan and Maseot, Knox Co.; Hodges, Jefferson Co.; Holston Station, Grainger Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

West of Mississippi:

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Distribution and Ecology in Pennsylvania (See fig. 7): This species is found in Pennsylvania, preëminently in the Ohio and Allegheny Rivers; from the localities in the Monongahela and Beaver, only single individuals are known. It prefers riffles with coarse gravel and strong current, and in Beaver Co. it is found upon the shell-banks in a strong and steady current. The same is true farther down the Ohio, where it is often obtained by the clam-diggers.

General distribution: Type locality, Falls of the Ohio (Rafinesque) at Louisville, Kentucky.

In the Allegheny River, at Templeton, Armstrong Co., and in the Monongahela, in Washington and Westmoreland Cos., Pennsylvania, this species reaches its highest points of advance in an upstream direction. Also Beaver River at Wampum, Lawrence Co., is an extreme point. Farther westward, its range follows the Ohio, and embraces, according to Simpson (1900), the Ohio, Cumberland, and Tennessee river-systems; west to Missouri and Minnesota. In the upper Ohio, it goes very little into the tributaries, and is known only from the Tuscarawas and Scioto in Ohio (Sterki, 1907*a*[49]), Wabash (Call, 1896*a* and 1900), and White River (Lea, Obs. X, 1863, p. 432) in Indiana. In Illinois it covers a large territory (Illinois River up to Kankakee and Fox Rivers). It also follows up the Mississippi and its tributaries in northern Illinois and eastern Iowa (Des Moines River, Witter, 1878, Call, 1885), and goes as far as Minnesota (Grant, 1886, and Holzinger, 1888).

West of the Mississippi, records are scarce or doubtful,[50] but the Carnegie Museum has it from the Meramec River, near St. Louis, and Utterback (1916)

[49] Sterki gives also the Mahoning River. I question this record, since I have never seen a trace of it in the lower Mahoning in Pennsylvania, and since Dean (1890) does not mention it.

[50] Seammon gives it as rare from Verdigris River in Kansas. A specimen from Wakarusa River, Lawrence, Douglas Co., Kansas, determined by Seammon as *P. æsopus*, and sent to the Carnegie Museum by R. L. Moodie, agrees very well with Seammon's figure (1908, pl. 78, fig. 2) but it is not this species. Our specimen is an old, dead shell, and probably an abnormal *Quadrula quadrula*.

mentions at least one place in western Missouri (Little Blue River, Courtney, Jackson Co., near Kansas City). The species has never been reported from the region of the lower Mississippi, and although Call (1896*a* and 1900) includes the Alabama River in its range, this record has not been confirmed by anybody else (See Lewis, 1877).

Genus Pleurobema Rafinesque (1820).

Ortmann, 1912, p. 261; Simpson, 1914, p. 732.

Type *Unio clava* Lamarck.

The conception of this genus has been changed greatly in recent times. In Pennsylvania, I distinguish two species, but one of them is quite polymorphous, with a number (five) of variations and ecological (or local) races or varieties.

Key to the Species and Varieties of Pleurobema.

a_1. Shell rather large, upright, or oblique. Epidermis chestnut to dark brown or blackish, with indistinct capillary rays, which generally are not broken up into blotches.

b_1. Shell not very oblique, more or less upright. Nacre white or red. Radial furrow strong, weak, or absent. Diameter variable.

c_1. Furrow strong or weak, but always present. Nacre white, very rarely red. Diameter mostly over fifty percent of length (very rarely less). Shape upright.

d_1. Outline subtriangular; furrow strong..... *P. obliquum.*

d_2. Outline rounded; furrow generally weak, but present..... *P. obliquum cordatum.*

c_2. Furrow generally absent (rarely a trace seen). Nacre white or red. Diameter variable. Shape subtriangular, upright, or slightly oblique.

d_1. Shell rather large. Growth lines irregular and indistinct. Epidermis dark.

e_1. Nacre white, rarely red. Diameter fifty percent of length or more. *P. obliquum catillus.*

e_2. Nacre white, salmon, or red. Diameter less than fifty percent of length. *P. obliquum coccineum.*

d_2. Shell smaller. Growth lines more distinct and regular. Epidermis lighter. *P. obliquum pauperculum.*

b_2. Shell very oblique, beaks directed anteriorly. Nacre generally red, rarely white. Furrow strong, rarely weak. Diameter mostly over fifty percent of length..... *P. obliquum rubrum.*

a_2. Shell rather small, very oblique, beaks located well anteriorly. Epidermis yellowish or light brown, with distinct rays, which are often broken up into blotches..... *P. clava.*

Pleurobema obliquum (Lamarck) (1819).

Quadrula obliqua (Lamarck) Simpson, 1914, p. 881.

Plate VI, figs. 4, 5, 8.

Records from Pennsylvania:

Call, 1885 (Allegheny River).

Harn, 1891 (western Pennsylvania).

Clapp, 1895 (Allegheny Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).[51]
Ortmann, 1909*b*, p. 199.

Characters of the shell: Shell rather large, heavy. Outline subtriangular, rounded before, subangular and more or less drawn out at the lower posterior end, with the lower margin gently convex in the anterior part, and generally concave in the posterior part, and with the supero-posterior margin gently curved. Beak more or less elevated, and swollen, directed obliquely forward, or more or less incurved, situated nearer to the anterior end of the shell. Beak-sculpture rudimentary, consisting of two or three indistinct, concentric bars. Shell rather swollen anteriorly, the diameter generally over fifty percent of the length. Posteriorly the shell is compressed, with a broad, more or less distinct, radial furrow, running from the beaks toward the lower posterior margin, producing there a shallow emargination. Surface of shell smooth, without any sculpture. Behind the radial depression there is a rounded, low elevation, which, however, does not form a distinct ridge, and passes insensibly into the posterior slope.

Epidermis lighter or darker brown, generally of a dark chestnut hue, blackish, when old, with fine and indistinct green or blackish capillary rays, or bundles of rays, which are mostly entirely obliterated in old specimens. The rays do not break up into blotches. Growth-rests more or less distinct, darker than the rest of the shell.

Hinge-teeth well-developed, rather strong. Pseudocardinals divergent, ragged. Interdentum rather wide. Lateral teeth moderately long. Beak-cavity more or less deep, often somewhat compressed. Dorsal muscle-scars on the hinge-plate. Nacre mostly white, rarely reddish.

No sexual differences in the shell.

	L.	H.	D.	Pr.ct.
Size: 1. Industry, Cat. No. 61.3900 (unusually produced)	109 mm.	82 mm.	46 mm.	.42
2. Industry, Cat. No. 61.3902	90 "	77 "	51 "	.57
3. Godfrey, Cat. No. 61.3901*a*	83 "	69 "	42 "	.51
4. Charleroi, Cat. No. 61.2869	59 "	52 "	33 "	.56

Soft parts (See Ortmann, 1912, p. 264). I have examined nearly a thousand individuals of this species, and have found the structure of the soft parts as described, with only the outer gills marsupial. However, a few exceptions have been noted in the case of five specimens received through the courtesy of Dr. R.

[51] As has been stated by the writer (1909*b*, pp. 186 and 199) only part of the specimens from Coraopolis, recorded by Rhoads, belong to *Pl. obliquum*, the rest are *Fusconaia subrotunda*, while all of Rhoads' specimens from Beaver (in the Philadelphia Academy) are *F. subrotunda*.

E. Coker, by whom they were collected in the Cumberland River, near Clarksville, Montgomery Co., Tennessee. In the extreme case about half of the inner gills, in their middle portion near the margins, was marsupial; in three other cases, much smaller sections of the inner gills were charged, and in one case a few eggs were near the central margin of the right inner gill. Along with these abnormal specimens, two were received with normal marsupium, but none had all four gills *fully* charged, as is the case in the genera *Fusconaia*, *Quadrula* etc.[52] It should be borne in mind that these specimens were selected and sent to me to demonstrate the fact that sometimes there are eggs in the inner gills. This observation does not invalidate the rule that this species *normally* has only the outer gills marsupial. Since the genus *Pleurobema* undoubtedly is descended from ancestral forms, which had all four gills marsupial (as for instance *Fusconaia*), it is not astonishing, that the present species sometimes reverts, although not fully, to this old condition (*Atavism*). From the genus *Fusconaia*, to which it is most closely allied by the shell, it differs nevertheless by the fact that the placentæ are always lanceolate, not subcylindrical, and that their color is always white, never red.

Glochidia (observed by myself only in the specimens just mentioned) agreeing in shape and size with those of *P. obliquum coccineum:* 0.15 × 0.15 mm. According to Surber (1915) they measure: 0.160 × 0.175 mm.

Breeding season: I have gravid females collected on the following dates: June 3, 1911; June 20, 1911; June 21, 1911; June 24, 1909. On the first date a specimen with glochidia was obtained. The species is apparently tachytictic, but the duration of the breeding season is not fully known. Surber's specimens with glochidia were collected on July 14.

Remarks: A quite characteristic species, in its typical phase (called "pig-toe" by the clam-diggers), but subject to an immense range of variation. The variations concern chiefly the general shape. While the typical form (See Pl. VI, fig. 4) is characterized by its subtriangular outline, by the rather upright shape, with the gently incurved beaks not situated at the anterior end, and by the well-developed radial furrow, all these characters may vary. The commonest variation is that in which the posterior lower angle becomes more or less produced, chiefly occurring in old shells (Pl. VI, fig. 8) so that the diameter becomes unusually low. It is, however, observable that such specimens, when young, were quite normal. In other specimens the beaks are more upright, making the whole shell appear higher and shorter. The radial depression is extremely variable, often different on the two sides of the same specimen, and tends in many specimens to

[52] Lefevre & Curtis (1912, p. 120) enumerate this species under the "Tetragenæ," where the marsupium comprises all four gills.

become effaced, leading thus to the var. *catillus* (Pl. VI, figs. 5, 6). Again the posterior angle of the shell may be less developed, and the posterior end may be shorter, a condition generally connected with a deficient development of the whole posterior slope, thus emphasizing the swollen anterior part of the shell. In such cases, the lower margin is more curved upward behind, producing a more rounded, not triangular outline, leading to the var. *cordatum*. The obesity of the shell, although always considerable, is variable, but there are no shells which could be called flat; yet in specimens with the posterior angle much drawn out, the posterior section of the shell may be flat (Pl. VI, fig. 8). The nacre is generally white, but individuals are occasionally found, where it is reddish.

Although the group of *P. obliquum* has been misunderstood by most authors, the main species has generally been properly recognized, and the references given by Simpson are correct. But the figure of Call (1900, Pl. 59, upp. fig.), under the name of *U. solidus*, should be added: it is a typical *P. obliquum*.

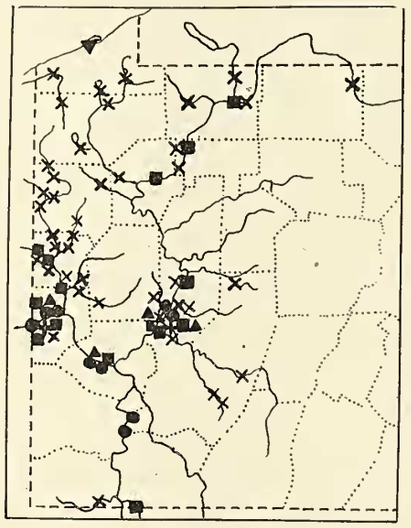


Fig. 8.

● *Pleurobema obliquum.*
+ *Pleurobema obliquum cordatum.*
■ *Pleurobema obliquum catillus.*
× *Pleurobema obliquum coccineum.*
▼ *Pleurobema obliquum paupereulum.*
▲ *Pleurobema obliquum rubrum.*

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Smiths Ferry (W. F. Graham), Shippingport, Cooks Ferry and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).

Allegheny River, Godfrey and Kelly, Armstrong Co.

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Beech Bottom, Brooke Co., West Virginia (W. F. Graham); Toronto, Jefferson Co., Ohio; Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Tuscarawas River, Ohio (Holland collection).

Cumberland-Tennessee-drainage:

Cumberland River, Clarksville, Montgomery Co., Tennessee (R. E. Coker donor).

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Knoxville and Brabsons Ferry, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Noeton and Holston Station, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co., Tennessee; Needham Ford, Union Co., Tennessee (B. Walker donor).

Distribution and Ecology in Pennsylvania (See fig. 8): The typical form of *P. obliquum* is restricted in Pennsylvania to the three large rivers, the Ohio, Allegheny, and Monongahela. In the Allegheny it is found as high up as Armstrong Co., but is not very abundant there. In the Monongahela, judging from the large number of specimens collected by G. A. Ehrmann, it must have been at one time abundant in the vicinity of Charleroi, but we do not know how far it ascended the river. In the Ohio below Pittsburgh it is a common shell. Farther down, it is extremely abundant, and is the prevailing species, at least locally. It is the shell, which largely contributes in forming the shell-banks, in rather deep, steadily flowing water, and, next to the "mucket" (*Actinonaias ligamentina*), it is the shell most highly valued by the clam-diggers. In Pennsylvania, it is present also in riffles, and immediately above them, in strong current, and among coarse gravel.

General distribution: Type locality, Ohio River (Lamarck).

On account of the great confusion prevailing with regard to this species, it is hard to make out the limits of its distribution, but it is certain that it chiefly inhabits the systems of the Ohio, Cumberland, and Tennessee Rivers. In the Ohio-drainage it does not go much into the tributaries, but is known from the Muskingum-Tuscarawas River in Ohio (Sterki, 1907*a*), and from the Wabash in Indiana (Call, 1896*a* and 1900). It occurs also in the Mississippi in Illinois (Baker, 1906), and goes northward into Wisconsin and Minnesota. It also has been reported from the Alabama River (Lewis, 1877, and Simpson, 1900), but this is doubtful. I have not seen any specimens of it in the collections made there by H. H. Smith.

The existence of typical *P. obliquum* becomes uncertain in the west and southwest. It has not been recorded by Scammon (1906) from Kansas, and although Call (1895, p. 32) cites it from the Ouachita River in Arkansas, I have never seen a genuine *P. obliquum* in all the rich material I have received from H. E. Wheeler taken from this river. In this region it seems to be entirely replaced by the vars. *catillus* and *rubrum*. Utterback (1916) failed to find this species in Missouri.

From what we know at present it is quite evident that the species prefers the larger rivers (See Call, 1900, p. 502) and thus it is easily understood why it has not migrated from the Mississippi-Ohio system into any other drainage.

Pleurobema obliquum cordatum (Rafinesque) (1820).

Quadrula plena (Lea) Simpson, 1914, p. 886; *Quadrula cordata* (Rafinesque) Vanatta, 1915, p. 558.

Plate VII, fig. 1.

No records from Pennsylvania previous to those given below.

Characters of variety: Much like typical *obliquum*, but shape more rounded, which is due to the slight development of the lower posterior angle and the whole posterior slope. In consequence of this, the shell appears more elevated and more upright. With regard to the diameter, the shell resembles *P. obliquum* (over fifty percent of length). The radial furrow is generally weak, but present. Nacre white, or slightly pink.

	L.	H.	D.	Pr.ct.
Size: 1. Cooks Ferry, Cat. No. 61.4434*b*	78 mm.	79 mm.	51.5 mm.	.66
2. Godfrey, Cat. No. 61.3901*b*	70 "	67 "	43 "	.61
3. Godfrey, Cat. No. 61.4378	56 "	57 "	34 "	.61

Soft parts and *glochidia* not observed in Pennsylvania. In the region of the upper Tennessee I found a few gravid females, but none with glochidia. The anatomy is the same as in the main species. Only the outer gills possess marsupial structure.

Breeding season: Gravid females were found on May 25, 1914.

Remarks: This form hardly deserves a varietal name, and I retain it only because it has been distinguished as a "species" by previous authors. In Pennsylvania, it is nothing but an individual variation, found very rarely, and always associated and intergrading with the typical form. The three specimens, of which measurements are given, are the only ones I have from Pennsylvania, and even these are not quite typical representatives of *cordatum*. In the upper Tennessee region, I have found this form more frequently, but also there it is by no means a well-defined race, and I know of no region, where *cordatum* is found pure.

Localities represented in the Carnegie Museum:

Ohio-drainage:

Allegheny River, Godfrey, Armstrong Co., Pennsylvania.

Ohio River, Cooks Ferry, Beaver Co., Pennsylvania.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Bridgeport, Jackson Co., Alabama (B. Walker, donor).

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Holston Station, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co., Tennessee.

Distribution (See fig. 8): *Type locality,* Ohio River (Rafinesque).

Wherever found, in Pennsylvania, as well as in the Tennessee-drainage, this form is associated with the main form, and does not show any remarkable facts in its distribution.

Pleurobema obliquum catillus (Conrad) (1836).

Quadrula solida (Lea) Simpson, 1914, p. 885; *Pleurobema obliquum catillus* (Conrad) and *Pleurobema catillus* (Conrad) Utterback, 1916, p. 79, 82.

Plate VI, fig. 6; Plate VII, fig. 2.

No records from Pennsylvania previous to those given below.

Characters of variety: This form may be briefly characterized as a *P. obliquum,* in which the radial furrow is obliterated. In all other respects it resembles the main species, and varies in the same way. The shell is more or less subtriangular, upright or somewhat oblique. The diameter is always considerable, fifty percent or more of the length. The nacre is generally white, rarely pinkish.

	L.	H.	D.	Pr.ct.
Size: 1. Industry, Cat. No. 61.3895	83 mm.	65 mm.	48 mm.	.58
2. Industry, Cat. No. 61.3895	81 "	69 "	45 "	.56
3. Godfrey, Cat. No. 61.4567	61.5 "	51 "	32 "	.52

Soft parts: Identical with those of the main form, and also the *glochidia.*

Breeding season: Gravid females were found on May 22, 1914; June 22, 1909; June 24, 1909. Glochidia on June 24. Specimens from the White River in Arkansas were gravid, containing eggs on August 2 and 5, 1914.

Remarks: This form likewise is not sharply separated from the main species, and is connected with it by very gradual transitions, but it has a better claim to be recognized as a variety than var. *cordatum,* since it seems to replace the main species at least in certain regions. It has been largely misunderstood by previous authors,

and even Simpson did not recognize it clearly. In fact, two of the specimens of which he published the measurements (the first two) fall under the var. *coccineum*. The synonymy given by Simpson is correct, as far as it goes. But there is no doubt that *U. catillus* Conrad (1836), which is made by Simpson a synonym of *U. coccineus* should be united with *U. solidus* Lea. Its diameter is fifty-one percent of the length (according to Conrad's figure, Pl. 13, fig. 2), and its greater obesity is precisely the character which distinguishes it from *U. coccineus*. *U. solidus* (according to Lea's figure) has a diameter of sixty percent of the length, while *U. coccineus* Conrad (*ibid.*, Pl. 13, fig. 1) has the diameter thirty-seven percent of the length.

That *U. catillus* more nearly approaches *U. solidus*, was already recognized by Utterback, who also clearly saw that these forms in Missouri pass into each other and into *obliquum*. Utterback tried to express this in a very peculiar way by naming one of the intergrades *P. catillus*, and another *P. obliquum catillus*, but this can hardly find approval.

The Carnegie Museum possesses, from the Hartman collection, a specimen (Cat. No. 61.1440) from Cincinnati, labeled *U. solidus*, "type" (meaning typical), and "Lea datum." This, consequently, is an authentic specimen from Lea, from one of the type localities. It has a diameter of sixty-four percent, and thus corresponds closely with Lea's original figure, and with my conception of this form.

That *U. solidus* of Call (1900, Pl. 59, upp. fig.) is a typical *P. obliquum*, has been mentioned above. What Scammon (1906, Pl. 85) figures as a young *Quadrula solida*, is not this, but a rather good *P. obliquum rubrum*.

Unio fulgidus Lea (Obs. IV, 1848, Pl. 4, fig. 10), supposedly from Alexandria, Louisiana, is made by Simpson a synonym of *Q. solida*. It is founded upon a very young specimen, and I hardly think that it is possible to make out what it really is. However, Walker has communicated under the name of *fulgidus* a specimen from Iowa City, which undoubtedly belongs to *solidus* (= *catillus*). It has a rather shining epidermis, but otherwise closely resembles specimens labeled *solidus* by Walker. Such specimens seem to prevail west of the Mississippi, but I have them also from the Tennessee-drainage.

In Pennsylvania, *P. obliquum catillus* may be recognized by the absence of the radial furrow, the sutriangular outline, and considerable obesity. By the reduction of the latter, *i.e.*, when the shell becomes more compressed, it passes very gradually into the var. *coccineum*, and it is possible to separate the transitional forms only by exact measurements, and an artificial dividing line. I have drawn this line at the diameter of fifty percent of the length, but I again must emphasize

that this is arbitrary, separating things which are actually connected. However, for practical purposes (naming of specimens) it is a great help, and serves to simplify matters.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Coraopolis, Allegheny Co. (S. N. Rhoads).

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Mahoning River, Mahoningtown and Coverts, Lawrence Co.

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Hickory, Forest Co.; Warren, Warren Co.

Cheat River, Cheat Haven, Fayette Co.

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Steubenville, Jefferson Co., Ohio (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio; Cincinnati, Hamilton Co., Ohio (Hartman collection).

Tuscarawas River, Ohio (Holland collection).

Tennessee-drainage:

Duck River, Columbia, Maury Co., Tennessee (B. Walker, donor).

Tennessee River, Florence, Lauderdale Co. (H. H. Smith); Bridgeport, Jackson Co., Alabama (B. Walker, donor).

Holston River, Noeton, Grainger Co., Tennessee.

Clinch River, Edgemoor, Anderson Co.; Black Fox Ford, Union Co., Tennessee.

West of Mississippi:

Iowa River, Iowa City, Johnson Co., Iowa (B. Walker, donor).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Marais des Cygnes River, Rich Hill, Bates Co., Missouri (W. I. Utterback).

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).

Black River (H. E. Wheeler) and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.

From other localities in southern Arkansas (Ouachita River) and in Oklahoma, similar forms are at hand, but I omit them here, since they require further study, chiefly with regard to their relation to the southwestern forms of *P. obliquum rubrum*, which are not at all clear. (See Wheeler, 1918, p. 124.)

Distribution and Ecology in Pennsylvania (See fig. 8): In the Ohio and Allegheny this form is found associated with typical *P. obliquum*. No specimens have come to hand from the Monongahela proper, but it must have existed there, since it turns up in the lower Cheat. In the Allegheny, it goes a great distance beyond the range of *P. obliquum*, up to Warren Co., but in this whole region it is associated with, and passes into, *P. obliquum coccineum*. It also has entered the Beaver River, and goes even up into the lower part of the Mahoning, passing again

into *coccineum*. It is interesting to see that it actually exists in the Mahoning, for one of the original localities mentioned by Lea for his *U. solidus*, is "Mahoning River, Ohio."

In the lower Allegheny and in the Ohio just below Pittsburgh, this form is even more abundant than the normal *P. obliquum*. It is found under the same conditions as the latter, but most abundantly upon gravel bars with strong current.

General distribution: Type locality, Scioto River, Ohio (Conrad).

This variety seems to be found wherever the typical form is present, that is to say, in the Ohio-, Cumberland-, and Tennessee-drainages; but particulars cannot be accurately expressed on account of the confusion which prevails with regard to it. It is certainly present in the upper Tennessee-drainage, going upstream about as far as *P. obliquum*. In addition this variety seems to be rather frequent west of the Mississippi, in regions where the typical *P. obliquum* is largely absent or doubtful, namely in Iowa, Missouri, and northern Arkansas. As has been indicated above, *P. catillus* seems there to replace *P. obliquum*, and in turn connects with the var. *rubrum*. This group of forms (*catillus-rubrum*) develops farther to the southwest into a peculiar assemblage, which cannot be discussed here. In Missouri there is shown a tendency on the part of *catillus* to pass into *coccineum* in small streams, exactly as is the case in Pennsylvania.

Pleurobema obliquum coccineum (Conrad) (1836).

Quadrula coccinea (Conrad) Simpson, 1914, p. 883.

Plate VII, figs. 3, 4, 5.

Records from Pennsylvania:

Conrad, 1836 (Mahoning River, near Pittsburgh).[53]
Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 200.

Characters of variety: Differs from *P. obliquum* by the flat and compressed shell, less prominent beaks, and the absence of the radial furrow. In the latter character, it agrees with *P. obliquum catillus*, but differs from this in the compression, the diameter being less than fifty percent of the length. The shape of the shell is subtriangular or, on account of the low beaks, more or less subovate. Color of nacre very variable: white, salmon, or all shades of pink to deep red.

[53] The nearest point of the Mahoning to Pittsburgh is where it joins the Shenango to form the Beaver, at Mahoningtown, Lawrence Co., Pa. I have found this form at this place, and this should be regarded as the *Type locality*.

	L.	H.	D.	Pr.ct.
Size: 1. Mt. Morris, Cat. No. 61.4574	111 mm.	88 mm.	43 mm.	.39
2. Larabee, Cat. No. 61.3350	100 "	81 "	49 "	.49
3. Eastbrook, Cat. No. 61.3349	88 "	67 "	32 "	.36
4. Mahoningtown, Cat. No. 61.3907	69 "	59 "	32 "	.46

Soft parts (See Ortmann, 1912, p. 263): I have seen several hundred females, many of them gravid, but in no case I have found marsupial structure in the inner gills. *Glochidia* (See Ortmann (1911*b*, Pl. 89, fig. 4) measurements: 0.15 × 0.15 mm., and Surber (1915, p. 7, fig. 9) measurements: 0.16 × 0.16 mm.).

Breeding season: Gravid females have been found on May 13, 1911; May 23, 1909; May 23, 1911; May 23, 1912; May 24, 1911; June 18, 1908; June 22, 1908; June 23, 1910; July 4, 1909; July 8, 1909; July 19, 1909. Glochidia have been found on June 18, June 23, and July 4. Thus this form is tachytictic, breeding from the middle of May to the middle of July, and beginning to discharge the glochidia in the second half of June.

Remarks: This form has been hitherto regarded as a good species. In its typical environment (small streams) it is, indeed, quite constant, although it varies a good deal. The shape may be different, from subrotund to subovate, or subtriangular, and quite often the lower posterior end is drawn out and even deflected, thus producing an outline recalling that of *P. obliquum rubrum.* Generally, there is no trace of a radial furrow, and the lateral faces are rather flat, only slightly convex, and without a posterior ridge. In obesity, this form varies greatly, and more swollen shells (See No. 2, under measurements) gradually pass into *P. obliquum catillus,* and this takes place in the downstream direction. In the upper Allegheny occasional individuals turn up, having the dimensions of *catillus;* such become more abundant in Armstrong Co., where they outnumber the *coccineum*-forms. Here also individuals turn up, which show the beginning of a radial furrow, which then lead to specimens with well-developed furrow, representing typical *obliquum.*

There is complete intergradation between these forms, and it is impossible to separate them except by drawing an artificial line.

Below Pittsburgh, in the Ohio, only a single *coccineum* has been found. Conditions similar to those in the Allegheny prevail in the Beaver-drainage.

The nacre of *coccineum* is of a reddish tint more frequently than is the case in any of the preceding forms.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio proper and Beaver-drainage:

Ohio River, Cooks Ferry, Beaver Co.

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith; G. L. Simpson, Jr.); Harmony, Butler Co.
Slipperyrock Creek, Wurtemberg, Lawrence Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Mahoning River, Mahoningtown (Type locality), and Coverts, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.

Allegheny-drainage:

Allegheny River, Aladdin, Godfrey, Kelly, and Templeton, Armstrong Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co.
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Crooked Creek, Rosston, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Conneauttee Creek, Edinboro, Erie Co.
Leboeuf Creek, Waterford, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.

Monongahela-drainage:

Dunkard Creek, Mount Morris, Greene Co.

Lake Erie-drainage:

Conneaut Creek, Springboro, Crawford Co.; West Springfield, Erie Co.[54]

Other localities represented in the Carnegie Museum:

Lake-drainage:

Shiawassee River, Genesee Co., Michigan (B. Walker, donor) (Saginaw-drainage).
Raisin River, Tecumseh, Lenawee Co., and Grape P. O., Monroe Co., Michigan (C. Goodrich).
St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

Ohio-drainage:

Mahoning River, Leavittsburgh, Trumbull Co., Ohio (Smith collection).
Tuscarawas River, Ohio (Holland collection).
Scioto River, Ohio (Hartman collection).
Wabash River, Geneva, Adams Co., and Bluffton, Wells Co., Ind. (C. Goodrich).
West Fork River, Lynch Mines, Harrison Co., West Virginia; West Milford, Harrison Co., West Virginia (W. F. Graham); Lightburn and Weston, Lewis Co., West Virginia.

[54] The specimens from Conneaut Creek, which flows to Lake Erie, are all typical, medium-sized *coccineum*, with red nacre, which color is never found in the lake-form, and are not the latter (*pauperculum*).

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
Little Coal River, Boone Co., West Virginia (Hartman collection).
Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Holston River, Hodges, Jefferson Co.; Noeton, Grainger Co., Tennessee.
Clinch River, Solway, Knox Co., Tennessee.

West of Mississippi:

James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Garfield, Benton Co., Arkansas (R. L. Moodie).

Distribution and Ecology in Pennsylvania (See fig. 8): In Pennsylvania, this form is widely distributed. It is especially abundant in the Beaver-drainage, and also in that of the upper Allegheny, going up far into the headwaters, reaching into Beaver and French Creek, Crawford and Erie Cos., and in the uppermost Allegheny, McKean Co. In the Monongahela-drainage, it is rare, at least in Pennsylvania, and found only in Dunkard Creek, but formerly it surely existed elsewhere in smaller creeks, which are now polluted. It becomes more abundant again in the headwaters of the Monongahela in West Virginia.

It is distinctly a form of the smaller creeks, and locally quite plentiful in them. It prefers sand and fine gravel, in or below riffles, where the current is rather lively, and generally it is deeply buried. It avoids coarse gravel, but may be found now and then in rough places.

As has been stated, farther down in the larger rivers, it passes into *P. obliquum catillus*, and with the change of the shape of the shell, there is also a change in its ecological preferences, or perhaps it might be true to say that the latter very likely is the cause of the former change. We have here a good example of the correlation of habitat and shape. *P. obliquum coccineum* is distinctly an ecological race of *P. obliquum* (and its variety *catillus*) characteristic of the fine gravel and sand of the smaller streams. In the Ohio below Pittsburgh *coccineum* is practically absent, only a single individual having been found.

Its presence in Conneaut Creek, a tributary of Lake Erie, should be noted. It appears that this form is not derived from the form found in Lake Erie (*pauperculum*), but is identical with the form present in the upper Beaver and French Creek-drainages. A crossing over the divide is in this case suggested, and it should not be forgotten, that the old Beaver Canal (now obliterated) once connected these systems.

General distribution: Type locality, Mahoning River, near Pittsburgh (Conrad) (See above, p. 78, footnote 53).

Simpson (1900) gives for this form: "entire upper Mississippi-drainage,"

while Call (1885) says: "from western New York to Kansas; south to the Holston River, Tennessee."

Very likely, this form is present in western New York in the Allegheny-drainage, judging from its presence in Pennsylvania both in Warren and McKean Cos., although Marshall (1895) reports it only from Lake Erie, no doubt referring to the variety *pauperculum*. In Ohio it is found all over the state (Sterki, 1907*a*), but definite reports are mainly from smaller streams.[55] It is known from the Mahoning River (Lea, Dean, 1890), Tuscarawas River (Dean, Sterki), Scioto River, and from Columbus (Lea). As in Pennsylvania so in Ohio it crosses over into the lake-drainage, and is found in the Cuyahoga (Dean) and Maumee-drainage (Carnegie Museum). It occurs also in the lake-drainage in southern Michigan (Walker, 1898). It is common in Indiana, and there also crosses into the lake-drainage, St. Marys and St. Josephs Rivers (Call, 1900). Wilson & Clark (1912, p. 42) observe that *coccineum* is found in the headwaters of the Kankakee River in Indiana, but that in the lower Kankakee and in the Iroquois River in Illinois it passes into a form belonging to the *obliquum*-group. In Illinois the same conditions seem to prevail (Baker, 1906) or at any rate it goes far up toward the north in that state.

As our localities show, this form is found in the tributaries of the Ohio in West Virginia and eastern Kentucky. Other records from Kentucky and from Tennessee are missing, except Call's statement, that it is found in the Holston. It is, indeed, present in the Holston and in the Clinch, but is quite rare there, and closely connected with the variety *catillus*.

Farther to the west and southwest there is the record from Coon River, Dallas Co., Iowa (Marshall, 1895), that from the drainage of Turkey, Wapsipinicon, and Volga Rivers, northeastern Iowa (Geiser, 1910), and that from Missouri (Utterback, 1916). It is said to be present in Kansas (Scammon, 1906), and is in northern Arkansas (see our specimens and Meek & Clark, 1912) and even in the Ouachita River, in Clark Co. (Wheeler, 1918). But in this direction, the limit of its range is obscure. It seems, that in this region likewise it prefers smaller streams, but this needs further investigation.

[55] Lea gives it from the Ohio at Marietta, Washington Co., Ohio, and it is in the Cincinnati-list (Harper, 1896); but these records are to be doubted. I have never found it in the Ohio, and the large shell-heaps of the clam-diggers examined by myself at various places never yielded a single individual of this shell.

PLEUROBEMA OBLIQUUM PAUPERCULUM (Simpson) (1900).

Quadrula coccinea paupercula SIMPSON, 1900, p. 789; *Quadrula subrotunda* STERKI, 1907*a*, p. 391 (*partim*); *Quadrula subrotunda* ORTMANN, 1909*b*, p. 203 (*per errorem*); *Quadrula coccinea magnalacustris* SIMPSON, 1914, p. 884.[56]

Plate VII, fig. 6.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 203 (as form of *Q. subrotunda*).

Characters of variety: Resembling *P. obliquum coccineum*, but shell considerably smaller, more convex (diameter ranges around fifty percent), with the outline subovate, and generally more elongate, and the growth-lines more distinct and quite regular. The beaks are not very prominent (hence the subovate, and not triangular, outline), and a furrow, except in extreme cases is absent, there being merely a flattening in its place. Nacre always white.

	L.	H.	D.	Pr.ct.
Size: 1. Erie, Cat. No. 61.4393 (largest at hand)	71 mm.	50 mm.	35 mm.	.49
2. Erie, Cat. No. 61.4393	70 "	55 "	34 "	.49
3. Erie, Cat. No. 61.4579	62 "	48 "	28 "	.45
4. Erie, Cat. No. 61.3930 (smallest at hand)	55 "	47 "	29 "	.53

Soft parts: Only two individuals have ever been found alive by myself, of which the soft parts of one were preserved. It proved to be a male, with the structure agreeing with that of *P. obliquum*. The characteristic features of the females have not been observed. The color of the soft parts was grayish-white.

Glochidia and *breeding season* unknown.

Remarks: As Simpson correctly recognized, this is a form derived from *coccineum*, and not directly from *obliquum:* nevertheless, the rules of nomenclature force us to use the above name.

This is the Lake Erie form of *coccineum*, descended from the stock which crossed the divide between the upper Ohio and the lake-drainages in northern Indiana, Ohio, and possibly Pennsylvania. This lacustrine form has the distinct and regular growth-lines, which are also more closely set, found so often in shells from Lake Erie, and this peculiarity together with its small size are its chief diagnostic characters. In shape it is generally more elongate-ovate than *coccineum*, but, according to the growth-lines, young specimens must be shorter and more rounded-ovate. On the average it is slightly more swollen than *coccineum*, but

[56] The change of the varietal name introduced by Simpson in 1914 is unnecessary. There is a *Unio pauperculus* Lea (1861) but this does not constitute a pre-occupation of the term *Quadrula coccinea paupercula*.

the difference in this respect is not great. There is much variation in shape, chiefly with regard to the elongation of the shell and the position of the beaks. In some specimens the beaks are much anterior, thus imitating the condition seen in *P. obliquum rubrum*.

The color of the epidermis is generally dark brown, but specimens from Michigan are light brown, with greenish capillary rays; however, these specimens are greatly water-worn.

I have not seen any specimens grading toward the parent-form, and for this reason, we might perhaps be justified in regarding this as a true species. Nevertheless I hesitate to take this course, since I consider my material (about fifteen specimens) as insufficient to settle this question.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Distribution and Ecology (See fig. 8): *Type locality*, St. Lawrence basin at Niagara Falls (Simpson).

Sterki mentions this form, as a dwarf race of *Q. subrotunda*, from the Ohio shores of Lake Erie. Walker gives it (1913, p. 29) from Lake Erie, and probably his *Q. subrotunda* refers to the same form. I have found it in Presque Isle Bay, and received specimens from La Plaisance Bay. Probably, Marshall's (1895) *U. coccineus* from Erie Co., New York, is also this.

Our present knowledge thus limits its range to Lake Erie and the Niagara River just below it. Simpson, indeed, says "and tributaries," but exact localities are not given.

In Presque Isle Bay I found this shell only on the North shore in a few feet of water upon pure sand, but most of my specimens were dead shells. It is decidedly rare at this locality.

Pleurobema obliquum rubrum (Rafinesque) (1820).

Quadrula pyramidata (Lea) Simpson, 1914, p. 888; *Quadrula rubra* (Rafinesque) Vanatta, 1915, p. 557.

Plate VI, fig. 7.

Records from Pennsylvania:

Harn, 1891 (as *mytiloides*) (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).
Ortmann, 1909*b*, p. 199 (under *obliqua*).

Characters of variety: Like *P. obliquum*, but shell very oblique, with the beaks

strongly procurved, and situated at the anterior end of the shell. Radial furrow more or less distinct. Diameter generally considerably over fifty percent of the length, but sometimes less. Nacre typically red, but sometimes pinkish or white.

	L.	H.	D.	Pr.ct.
Size: 1. Industry, Cat. No. 61.3896	91 mm.	73 mm.	54 mm.	.59
2. Kelly, Cat. No. 61.3079	86 "	71 "	47 "	.55
3. Godfrey, Cat. No. 61.3891	63 "	53 "	36 "	.57

Soft parts (See Ortmann, 1912, p. 264): *Glochidia* not yet observed.

Breeding season: Gravid specimens are at hand collected on May 25, 1914 and July 28, 1913. They all had eggs only.

Remarks: There is not the slightest doubt that this is in Pennsylvania only an individual variation of *P. obliquum*, characterized by excessive obliquity. There is great variation in this respect, and complete connection with the main form. While the nacre is mostly red in typical specimens from the Tennessee, in Pennsylvania it is more frequently pink or whitish. Altogether, typical *rubrum* is quite scarce in our state, but, as our fig. 7 on Pl. VI shows, it is present, and does not differ at all from specimens from the Tennessee. The intergrades toward *P. obliquum* are much more abundant with us.

Considering the conditions in Pennsylvania alone, I should never have thought of giving this form varietal rank. But in other regions, it is more distinctly marked, as for instance in the Upper Tennessee-drainage. Here the var. *rubrum* in its typical phase is quite abundant and rather sharply distinguished. However, here also are found forms representing transitions to *obliquum* and *catillus*. In the region west of the Mississippi, where *P. obliquum* is practically missing, the var. *rubrum* (and *catillus*) are found in its place, and thus it seems to be advisable to retain *rubrum* as a distinct variety. These western forms require still closer study.

I want to emphasize this instance, for it demonstrates that a certain form may be in a certain region an individual variation of another form, while in other regions it becomes a better defined local race, or variety.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport and Industry, Beaver Co.; Neville Island, Allegheny Co.
Allegheny River, Godfrey and Kelly, Armstrong Co.

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, St. Marys, Pleasants Co., West Virginia; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
West Fork of White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Tennessee-drainage:

Tennessee River, Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor and Offutt, Anderson Co.; Needhams Ford (B. Walker, donor) and Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee.

There are a good many specimens at hand from west of the Mississippi, from Arkansas, Kansas, and Oklahoma, but since these form a peculiar and rather obscure association of forms, partly intergrading with the var. *catillus*, partly having characters of their own, I omit them here, till further investigations have been made.

Distribution in Pennsylvania (See fig. 8):

The range of this form in Pennsylvania, is coëxtensive with that of *P. obliquum*, but it is rather rare. The same is true farther down the Ohio, and wherever I collected it myself between Pittsburgh and Cincinnati I found only a few specimens of it among large numbers of *obliquum* and its intergrades.

General distribution: Type locality, Kentucky River (Rafinesque).

Where *P. obliquum* is found, this form generally is also present. However, *P. obliquum rubrum* seems to have a wider range than the main form, for it is also found west of the Mississippi without being associated with *P. obliquum* (See above). I also have observed in the upper Tennessee-drainage, that it ascends in the Holston and Clinch a little farther than the main species.

Note: Attention should be called again to the fact, that we have here a group of forms (*obliquum-group*), of which some have swollen shells (*obliquum* and *catillus*), which are found in the larger rivers, while another allied form has a compressed shell (*coccineum*), which is peculiar to small creeks. As in certain other cases, there is also a dwarfed lacustrine form, *pauperculum*.

It is well to keep these facts in mind. My observations on the passing of the creek form into that of the large rivers have been confirmed for the Kankakee-drainage in Indiana and Illinois by Wilson & Clark (1912, p. 42). However, the remark of these authors, that I am of the opinion that these forms are "identical" rests upon a misunderstanding. They are "conspecific," and represent well marked races, or varieties, of the same species, but they are not *identical*.

Pleurobema clava (Lamarck) (1819).

Pleurobema clava (Lamarck) Simpson, 1914, p. 735.

Plate VII, figs. 7, 8, 9.

Records from Pennsylvania:

Call, 1885 (Allegheny River, as *U. patulus*).

Harn, 1891 (western Pennsylvania).

Marshall, 1895 (Allegheny River, Warren Co.).
Ortmann, 1909*b*, p. 197.

Characters of the shell: Shell small, or barely of medium size, but comparatively heavy. Outline subtriangular to subovate, more or less elongated and drawn out posteriorly, very oblique, often cuneiform (high in front, tapering behind). Lower margin convex or straight. Beaks not much elevated, moderately swollen, directed obliquely forwards, and situated near the anterior end of the shell, sometimes quite anterior. Beak-sculpture rudimentary, indistinct, consisting of three to four subconcentric ridges. Shell more or less swollen anteriorly, less swollen and more compressed posteriorly; sometimes with the anterior swelling marked off quite sharply from the posterior flat part, but hardly ever with a distinct radial depression. In most cases the swollen anterior part passes insensibly into the compressed posterior part. In some cases the shell is very little swollen anteriorly, and the valves are rather regularly and gently convex. No distinct posterior ridge. Surface of shell smooth, without sculpture.

Epidermis yellowish to light brown or pale chestnut, darker when old; generally with more or less distinctly green capillary rays, which are interrupted and much broken, forming very often, and characteristically, squarish, or even transverse green to blackish spots or blotches. Growth-rests not very different in color.

Hinge well-developed. Pseudocardinals divergent, moderately large, ragged. Interdentum not very wide, often rather narrow. Lateral teeth rather long. Beak-cavity not deep. Dorsal muscle-scars on the hinge-plate. Nacre always white.

No sexual differences in the shell.

	L.	H.	D.
Size: 1. Harbor Bridge, Cat. No. 61.3815 (largest)	78 mm.	51 mm.	36 mm.
2. Eastbrook, Cat. No. 61.3335	74 "	48 "	27 "
3. Eastbrook, Cat. No. 61.3335	64 "	40 "	23 "
4. Eastbrook, Cat. No. 61.3335	54 "	35 "	21 "
5. Mosgrove, Cat. No. 61.4328	39 "	29 "	19 "

Soft parts (See Ortmann, 1912, p. 264, fig. 9). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 5).

Breeding season: The following records are at hand for gravid females: May 22, 1912; May 23, 1911; May 23, 1912; May 24, 1911; June 18, 1908; June 27, 1910; July 8, 1909; July 8, 1911; July 10, 1908; July 19, 1909. Glochidia have been found as early as June 18. Tachytictic form, breeding from about the middle of May to the end of July.

Remarks: A very distinct species, at least in Pennsylvania. It belongs to

the smaller mussels, and its chief characters are the peculiar, obliquely-ovate, elongated or cuneiform outline, and the light color of the epidermis, with green patches, which are frequently (but not always) present. In shape, situation of beaks, and obesity, it varies greatly (compare, for instance the figure of Lea's *patulus*, Obs. I, 1834, Pl. 12, fig. 20, and of Conrad's *clava*, Mon. 1835, Pl. 5, fig. 1). In old specimens the beaks are sometimes quite anterior, forming the foremost point of the shell, but such extremes are rare in Pennsylvania, and generally the beaks remain a little behind the anterior margin of the shell. Also with regard to the convexity of the valves no extreme cases have been observed in Pennsylvania; on the contrary the tendency is more toward the flatter types (corresponding more nearly to *patulus*).

The peculiar color-markings are present in most specimens, but extremely variable. The spots are found chiefly towards the beaks, and often an irregular

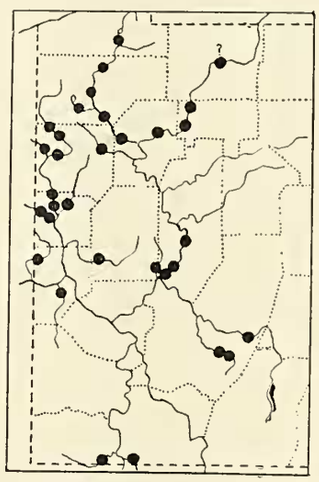


Fig. 9.

● *Pleurobema clava.*

series of these spots runs down just in front of the posterior slope. In old shells, the epidermis tends to become uniformly brown.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio-drainage:

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White).

Raccoon Creek, Raccoon Township, Beaver Co.

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Harmony, Butler Co.

Mahoning River, Mahoningtown and Coverts, Lawrence Co.

Neshannock Creek, Eastbrook, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.

Allegheny-drainage:

Allegheny River, Aladdin, Godfrey and Mosgrove, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.

Monongahela-drainage:

Dunkard Creek, Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Maumee River, Defiance, Defiance Co., Ohio, and Fort Wayne, Allen Co., Indiana (C. Goodrich).

Ohio-drainage:

Tuscarawas River, Ohio (Holland collection).
Wabash River, Geneva, Adams Co., Indiana (C. Goodrich).
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Sutton and Gassaway, Braxton Co.; Shelton, Clay Co., West Virginia.

Tennessee-drainage:

Tennessee River, Tuscumbia, Colbert Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 9): The range of this species in Pennsylvania is very similar to that of *P. obliquum coccineum*, with the exception that it does not go into the lake-drainage. The two forms are very often found associated. *P. clava* does not go up the Allegheny as far as *coccineum* does.[57]

Altogether, *P. clava* is a rare shell, and never found in great numbers. It is found mostly in sand and fine gravel, and is deeply buried. In the large rivers it is missing. The lowest point in the Allegheny is at Aladdin. It has never been found in the Monongahela proper and in the Ohio, and is also missing in the lists of the older collectors (Stupakoff, Clapp, Rhoads). The same holds good farther down the Ohio. I have never seen a trace of it between Pittsburgh and Cincinnati.

General distribution: Type locality, "Lake Erie" (Lamarck).

[57] I found *P. clava* as far up as Hickory, Forest Co., but Marshall (1895) reports it from Warren Co.

We have here the curious fact that a species is not found at its type locality. It should be noted, however, that this species is present in tributaries of the lake, chiefly in the Maumee (Goodrich, 1914) substantiated by specimens in the Carnegie Museum.

Although Call (1895 and 1900) cites western New York and the Ottawa River, Canada, for this species, there is serious doubt whether it goes so far north and northeast. No exact localities are known in the Allegheny River in the state of New York, nevertheless this species might be there, since it has been reported from Warren Co., Pennsylvania, and is positively found immediately below in Forest Co. Its main range includes the Ohio, Cumberland, and Tennessee systems, chiefly in their tributaries. It is widely distributed in these drainages in western Pennsylvania, Ohio, Indiana, West Virginia, Kentucky, Tennessee, and northern Alabama. In Ohio and Indiana it surely crosses over into the lake-drainage, St. Marys and Maumee Rivers (Call, 1900, and Sterki, 1907*a*, also collected by C. Goodrich). Nevertheless it has not been reported from Lakes Erie and Michigan (See Walker, 1898 and 1913). Remarkably enough, while it is widely distributed in Indiana (Call, 1896*a* and 1900), it is listed from Illinois (by Baker, 1906) only from the Wabash. Its actual absence in the rest of Illinois is confirmed by the recent investigations of Wilson and Clark. According to them it is in Tippecanoe Lake (Wabash-drainage) in Indiana, but not in the Kankakee-drainage in Indiana and Illinois. West of Illinois, only three records are at hand (from Iowa City, Iowa; St. Peters River, Minnesota; and Nebraska), which, however, are very likely incorrect (Simpson, 1900, p. 746 seems to have no confidence in them, and Geiser (1910) does not give this shell from northeastern Iowa). No other records are known from west of the Mississippi.

In the Tennessee-drainage, this species surely goes to northern Alabama. In the upper Tennessee region it is missing but there are a number of closely allied species or forms, the standing of which will be elucidated elsewhere; also in the Coosa-Alabama-drainage there are representatives, which have been taken for synonyms, for instance by Call. But this surely is incorrect, and requires further study.

It is not known, whether this species outside of Pennsylvania inhabits preferably the smaller streams, except that it is surely present in them in West Virginia.

Genus Elliptio Rafinesque (1820).

Ortmann, 1912, p. 265; Simpson, 1914, p. 586 (as section of *Unio*).

Type *Unio nigra* Rafinesque.

Five species and one variety are found in Pennsylvania (one of them somewhat doubtful as to its presence in the state).

Key to the Pennsylvanian Species and Variety of Elliptio.

a_1. Shell very large, rhomboid-ovate, not elongated, with a sharp posterior ridge. Posterior slope (at least in the young) with radiating wrinkles. (Western shell.) ..... *E. niger.*

a_2. Shell larger or smaller, elongated ovate, or subtrapezoidal, with ill defined or no posterior ridge. Posterior slope not wrinkled.

b_1. Shell rather large, elongated ovate, heavy, not subtrapezoidal, somewhat inflated or subcompressed. (Western shells.)

c_1. Shell larger, subcompressed. Epidermis dark colored, with obscure growth-lines. *E. dilatatus.*

c_2. Shell smaller, more swollen and thus more nearly subcylindrical. Epidermis of lighter color, with more distinct and more regular growth-lines..... *E. dilatatus sterkii.*

b_2. Shell moderately large or small, subtrapezoidal, more or less elongated, and more or less compressed. (Eastern shells.)

c_1. Shell moderately large, subtrapezoidal, slightly elongated, not much pointed behind. *E. violaceus.*

c_2. Shell moderately large or small, subtrapezoidal, but much elongated, so as to become lance-shaped, pointed behind.

d_1. Shell rather small, upper and lower margins nearly parallel; greatest height in the middle portion..... *E. cupreus.*

d_2. Shell somewhat larger, upper and lower margins not subparallel; greatest height more anteriorly..... *E. fisherianus*

Elliptio niger (Rafinesque) (1820).

Unio crassidens Lamarck. Simpson, 1914, p. 606.

Plate VIII, fig. 1.

Records from Pennsylvania:

Call, 1885 (Allegheny River).
Harn, 1891 (western Pennsylvania).
Clapp, 1895 (Allegheny Co.).
Marshall, 1895 (Allegheny River, Warren Co.).[58]
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, p. 197.

Characters of the shell: Shell large and very heavy. Outline ovate-rhomboid, rather variable, shorter or longer, but always longer than high, but rarely almost

[58] This record is doubtful. I have never seen this striking shell in the Allegheny above Oil City.

twice as long as high. Anterior end rounded, lower posterior end more or less produced and bluntly pointed. Lower margin convex, straight, or even sometimes slightly concave in its posterior part. Beaks not greatly swollen and not very prominent, situated in advance of the middle of the shell, but not very near the anterior end. Beak-sculpture very rudimentary, almost obliterated, consisting of a few weak concentric ridges running parallel with the growth-lines. Shell moderately swollen towards the beaks, but sides of the disk only gently convex, often quite flat posteriorly. A distinct and rather sharp posterior ridge runs from the beaks toward the lower posterior end. The posterior slope behind this ridge is subtruncate and flat, and toward the beaks it is generally ornamented with fine radiating wrinkles or corrugations. The latter are chiefly seen in young shells, are irregular and often interrupted. Upon old shells they are absent, mostly destroyed by the erosion of the beaks; sometimes they occur also in young specimens poorly developed, or are absent. Otherwise the surface of the shell is smooth, without sculpture.

Epidermis brown, from reddish brown to dark blackish brown; in the young it is lighter brown, and generally marked by dark green, obscure rays, which are narrower or wider, but in adult shells the rays disappear entirely. Growth-rests not distinctly marked by color.

Hinge-teeth well-developed and very strong. Pseudocardinals divergent, large, and ragged. Interdentum rather narrow. Lateral teeth thick and rather long. Beak-cavity not deep. Dorsal muscle-scars on the hinge-plate. Nacre always some shade of red. Very rarely it is almost white in the centre of the shell, and then some color is always present around the margins. In most cases, the whole nacre is tinted, and the color ranges from a beautiful salmon through all shades of pink and red to a blueish purple.

No sexual differences in the shell.

	L.	H.	D.
Size: 1. Kelly, Cat. No. 61.3777	129 mm.	85 mm.	49 mm.
2. Cooks Ferry, Cat. No. 61.4427	125 "	87 "	57 "
3. Kelly, Cat. No. 61.3055	117 "	73 "	44 "
4. Neville Island, Cat. No. 61.926	119 "	85 "	56 "
5. Kelly, Cat. No. 61.3059	89 "	60 "	43 "
6. Shippingport, Cat. No. 61.4607	63 "	42 "	23 "

Soft parts (See Ortmann, 1912, p. 266, fig. 10). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 6) not quite mature, size: 0.13 × 0.15 mm. Mature glochidia have been described and figured by Surber (1915, p. 8, fig. 13). Their shape is somewhat pointed (subtriangular); their size: 0.15 × 0.16 mm.

Breeding season: Gravid females have been found only once by myself, on June 22, 1909 (with eggs and young glochidia). Surber secured them on July 14, 1911. Thus the duration of the breeding season remains uncertain, but probably is short, and ends in July.

Remarks: A very characteristic species, which cannot be confused with any other form. In fact Rafinesque's definition of *U. nigra* as a "large, heavy shell,

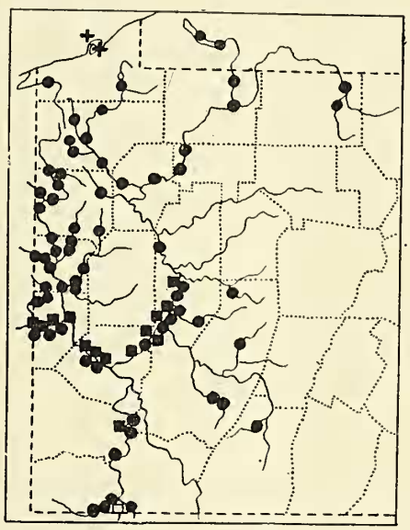


Fig. 10.

■ *Elliptio niger.*
□ *do.* *do.* (Indian garbage heap.)
● *Elliptio dilatatus.*
+ *Elliptio dilatatus sterkii.*

with red nacre, from the Ohio," is entirely satisfactory. The shell varies greatly in shape, and may be shorter or longer in proportion to height, but is always recognized by its subovate outline, the distinct posterior ridge, and the color of the nacre. The peculiar sculpture of the posterior slope is well-developed only in young shells.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Smiths Ferry (W. F. Graham), Shippingport, Cooks Ferry, Industry, and Beaver, Beaver Co.; Shoustown (R. Fœrster), Coraopolis (S. N. Rhoads), and Neville Island, Allegheny Co.

Allegheny River, Harmarville and Natrona, Allegheny Co.; Braeburn, Westmoreland Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Elk River, Gassaway, Braxton Co., and Shelton, Clay Co., West Virginia.

Levisa Fork, Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Concord and Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Noeton, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Sullivan Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Emory River, Harriman Junction, Roane Co., Tennessee.

Gulf-drainage:

Pearl River, Mississippi (Juny collection).

Black Warrior River, Squaw Shoals, Jefferson Co., Alabama (H. H. Smith).

Cahaba River, Pratts Ferry, Bibb Co., and Gurnee, Shelby Co., Alabama (H. H. Smith).

Coosa River, Wetumpka, Elmore Co.; Weduska and Peckerwood Shoals, and Wilsonville, Shelby Co.; Coosa Valley and Riverside, St. Clair Co., Alabama (H. H. Smith).

Choccolocco Creek, Jackson Shoals, Talladega Co., Alabama (H. H. Smith).

Chattooga River, Cedar Bluff, Cherokee Co., Alabama (H. H. Smith).

Etowah River (R. E. Call) and Oostanaula River (G. H. Clapp, donor), Rome, Floyd Co., Georgia.

Sepulga River, Herbert, Conecuh Co., Alabama (Alabama Museum, donor).[59]

Distribution and Ecology in Pennsylvania (See fig. 10): This is a species restricted to the large rivers, Ohio, Allegheny, and Monongahela, but extremely abundant in them. I have never seen it in the Allegheny above Templeton in Armstrong Co. In the Monongahela it once must have gone up above Charleroi at least as far as the West Virginia state-line, since I have found it in an Indian garbage-heap at Point Marion (See Ortmann, 1909*c*, p. 13).

Elliptio niger lives preferably in coarse gravel, often among heavy stones, in strongly flowing water, to which habitat it is especially adapted by its heavy, strong shell. Call (1900, p. 510) gives as its habitat "muddy bottoms," which is

[59] The specimens from the Coosa-drainage have in part been labeled by Walker as *U. incrassatus* Lea. But I consider them to be *E. niger*. They reach a considerable size, while the real *U. incrassatus* from the Chattahoochee River is a dwarf form.

not at all true for Pennsylvania. In the Ohio this shell is also found in great numbers on the shell-banks, consisting of masses of dead and broken shells, the interspaces filled with sand and gravel, in strong, steady currents. The same is the case farther down the Ohio, where it is taken in immense numbers by the clam-diggers, but rejected on account of the color of its nacre.

General distribution: Type locality, Ohio River (Rafinesque).

A common shell all along the Ohio from western Pennsylvania through Ohio, West Virginia, Kentucky, Indiana, and Illinois. Also in the Mississippi in Illinois, Iowa, and North to Minnesota, Winona Co. (See Holzinger, 1888). It goes only into the larger tributaries. In Ohio, it is in the Muskingum River at Marietta, Washington Co. (Hildreth, 1828), but not in the Tuscarawas River; it occurs in the Scioto River (Sterki, 1907*a*). In Indiana it is known from the Wabash (Call, 1900, Goodrich, 1914), and White River (Carnegie Museum). In Illinois it is found in the Wabash, and also in the Kaskaskia and Spoon Rivers (Baker, 1906). In Iowa, it is in the Wapsipinicon, at Independence, Buchanan Co. (Geiser, 1910). In West Virginia, I have discovered it in Elk River (tributary to the Kanawha). This river, and the Levisa Fork of the Big Sandy, are the smallest streams, in which I have found it.

Additional records from Kentucky are missing, but this species is known from the Cumberland, Tennessee, Duck, Holston, and Clinch Rivers in Tennessee.

In addition, it is widely distributed in the Alabama-drainage. The connection of this range with the main range seems to be over the Gulf plain; but this requires further study. The form from Alabama is indistinguishable from the Ohio form, but, judging from the material at hand, not quite so large. Eastward in the Chattahoochee in Georgia this form passes into a still smaller form, called *E. incrassatus*.

Elliptio dilatatus (Rafinesque) (1820).

Unio gibbosus Barnes. Simpson, 1914, p. 597; *Unio dilatata* Rafinesque, Vanatta, 1915, p. 555; *Elliptio dilatata* (Rafinesque) Utterback, 1916, p. 90.

Plate VIII, fig. 2.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).

Stupakoff, 1894 (Allegheny Co.).

Marshall, 1895 (Allegheny River, Warren Co.).

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).

Ortmann, 1909*b*, p. 197.

Characters of the shell: Shell rather large and heavy. Outline elongate-ovate, generally about twice as long as high, and often longer. Anterior end rounded, posterior end produced and narrowing, but blunt. Lower margin gently convex, straight, or even slightly concave. Upper margin curving gently down into the upper posterior margin, without forming a distinct angle, and thus the shell is not subtrapezoidal. Beaks not prominent, situated near the anterior end. Beak-sculpture distinct, consisting of four to five rather heavy bars; the first two are subconcentric, the following ones run in the direction of the growth-lines, are almost straight in the middle, with the anterior and posterior parts obliterated; sometimes an indication of a sinuation is seen a little behind the middle. Shell somewhat swollen in the anterior part and toward the beaks; less swollen and almost flat, sometimes even compressed posteriorly and toward the lower margin, without a distinct posterior ridge. Surface smooth, without any sculpture.

Epidermis brown to black. In young specimens, traces of greenish rays are discernible, but generally the color is rather uniform, and the growth-rests are likewise not marked by darker color.

Hinge-teeth well-developed, but not very heavy. Pseudocardinals divergent, ragged. Interdentum rudimentary or absent. Lateral teeth long. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre white or variably colored from light pink and salmon to deep purple, and coppery purple; often parti-colored, white and salmon, white and purple, salmon and purple, etc.

No sexual differences in the shell.

	L.	H.	D.	Pr.ct.
Size: 1. Jamestown, Cat. No. 61.3752 (largest at hand)	136 mm.	61 mm.	33 mm.	.24
2. Industry, Cat. No. 61.3763	122 "	55 "	33 "	.27
3. Greenville, Cat. No. 61.3329	91 "	37 "	27 "	.30
4. Wampum, Cat. No. 61.2889	54 "	26 "	13 "	.24

Soft parts (See Ortmann, 1912, p. 271). The *Glochidia* have been figured by Lea (Obs. XIII, 1874, Pl. 21, fig. 10), by Lefevre & Curtis (1910, p. 97, fig. N, & 1912, p. 146, fig. O) by Ortmann (1911*b*, Pl. 89, fig. 7) and Surber (1912, Pl. 2, fig. 38).

Breeding season: I have found several hundreds of gravid females on numerous dates between May 11 and August 13. Glochidia have been seen as early as June 5; but on the latest date (August 13) a specimen with eggs was observed. This is clearly an abnormal case. Surber (1912, p. 7) gives the breeding season as from June to August, but it begins before the middle of May. The species is typically tachytictic.

Remarks: I know of only two species in Pennsylvania, with which the present species might be confounded according to the general shape: *Ellipsaria fasciolaris* (Rafinesque) and *Eurynia recta* (Lamarck). The former is easily distinguished by the light, yellowish brown color of the epidermis, variegated with green rays and blotches; the latter is a straighter shell, more pointed behind, with a greenish black and shining epidermis.

Elliptio dilatatus is variable chiefly in size. In the larger rivers generally, and sometimes also in smaller creeks, it grows to a considerable length; while in other streams, chiefly those of the mountains, it remains rather small. Its general shape is rather uniform: it always is an elongated shell, produced and tapering behind, with no indication of a trapezoidal outline, and with a bluntly pointed posterior end. Its nacre is very variable in color, but while in the Ohio and Allegheny all shades are found, and shells with white nacre are quite abundant, in other sections, as for instance in the whole Beaver-drainage, shells with light-colored nacre are extremely rare. There is no tendency to form local races, except that a dwarfed form prevails in the mountain-streams.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Smiths Ferry, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Little Beaver Creek, Cannelton (Miss Vera White), Darlington, and New Galilee, Beaver Co.; Enon Valley, Lawrenee Co.

Beaver-drainage:

Beaver River, Wampum, Lawrenee Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrenee Co. (G. L. Simpson, Jr.).

Slipperyroek Creek, Wurtemberg and Rose Point, Lawrenee Co.

Wolf Creek, Grove City, Mereer Co.

Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrenee Co.

Neshannoek Creek, Eastbrook and Volant, Lawrenee Co.; Leesburg, Mereer Co.

Shenango River, Harbor Bridge and Pulaski, Lawrenee Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mereer Co.

Pymatuning Creek, Pymatuning Township, Mereer Co.

Little Shenango River, Greenville, Mereer Co.

Allegheny-drainage:

Allegheny River, Natrona, Allegheny Co.; Schenley, Aladdin, Godfrey, Johnetta, Kelly, Mosgrove, Templeton, and Parkers Landing, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hiekory, Forest Co.; Warren, Warren Co.; Larabee, MeKean Co. (Dennis Dally).

Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.[60]

Yellow Creek, Homer, Indiana Co.

[60] Dead shells have been seen in the Conemaugh River, at New Florenee, Westmoreland Co.

Quemahoning Creek, Stantons Mill, Somerset Co.
Crooked Creek, Rosston and South Bend, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

Monongahela-drainage:

Monongahela River, Westmoreland Co. (G. A. Ehrmann); Charleroi, Washington Co. (G. A. Ehrmann); Millsboro, Washington Co. (J. A. Shafer).
Dunkard Creek, Wilcy, Dunkard, and Mount Morris, Greene Co.[61]
Cheat River, Cheat Haven, Fayette Co.

Lake Erie-drainage:

Conneaut Creek, West Springfield, Erie Co.

Locality in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Beaver, Beaver Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum.

Lake-drainage:

Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Monroe and Grape P. O., Monroe Co., Michigan (C. Goodrich).
Kalamazoo, Kalamazoo Co., Michigan (Hartman collection).

Ohio-drainage:

Chautauqua Lake, Chautauqua Co., New York.[62]
Tuscarawas River, Ohio (Holland collection).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Hascman).
Wabash River, Bluffton, Wells Co., Indiana (C. Goodrich); White Co., Illinois (G. H. Clapp, donor).
Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Cheat River, Jaco, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Harrisville (W. F. Graham) and Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Pool of Kanawha River, Glen Ferris, Fayette Co., West Virginia.

[61] Dead shells have been seen in Tenmile Creek, Amity, Washington Co.

[62] Particulars about these see below, under var. *sterkii*.

Greenbrier River, Ronceverte, Greenbrier Co., West Virginia.
New River, Hinton, Summers Co., West Virginia; Pearisburg, Giles Co., Virginia.
Reed Creek, Wytheville, Wythe Co., Virginia.
Licking River, Farmer, Rowan Co., Kentucky.

Cumberland- and Tennessee-drainage:

Cumberland River, Orby, Bell Co., Kentucky.
Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Flint River and Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Tennessee River, Knoxville, Knox Co., Tennessee.
French Broad River, Boyd Creek, Sevier Co., Tennessee.
Little Pigeon River, Sevierville, Sevier Co., Tennessee.
Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill and Church Hill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.
Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia.
Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co.; Fink and Cleveland, Russell Co.; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.
Emory River, Harriman, Roane Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.
Wallen Creek, Lee Co., Virginia (G. H. Clapp, donor).

Mississippi and westwards:

Minnehaha Falls, Minneapolis, Hennepin Co., Minnesota (P. E. Nordgren).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).
Black River (H. E. Wheeler), and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).[63]
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).[64]
Neosho River, Kansas (R. L. Moodie); Miami, Ottawa Co., Oklahoma (F. B. Isely).
Wea Creek and Bull Creek, Miami Co., Kansas (C. Goodrich donor) (Osage-drainage).

Alabama-drainage:[65]

Buttahatchee River, Hamilton, Marion Co., Alabama (H. H. Smith).
Sipsey River, Elrod, Tuscaloosa Co.; Fayette, Fayette Co., Alabama (H. H. Smith).

[63] A peculiar race, dwarfed, nacre white, inclining toward var. *subgibbosus* (Lea).

[64] Mostly the var. *subgibbosus*, but some are undistinguishable from the normal form. (See Wheeler, 1918.)

[65] Alabama specimens are largely the var. *subgibbosus*. But the specimens recorded here are typical *dilatatus* (often intergrading with *subgibbosus*).

Cahaba River, Gurnee, Shelby Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 10): In the Ohio and Lake-drainage of western Pennsylvania this is, next to *Strophitus edentulus*, the most abundant species. It is practically ubiquitous, and there are few streams, which contain any shells, in which it has not been found. It is moreover common in the large rivers as well as in small creeks, and in some of the latter it is the leading form.

This wide and universal distribution undoubtedly is due to the fact, that this species is not very particular with regard to its station, and it is hardly possible to say that it prefers any definite ecological conditions. It is found in riffles in small streams, as well as among heavy rocks in the larger rivers; it is upon the shell-banks of the Ohio, as well as in quiet pools and eddies with muddy bottom; it is in lakes upon sandy, gravelly, and muddy bottoms. Nevertheless the uniformity of its characters is quite remarkable, and even beyond the limits of Pennsylvania there is hardly any change.

General distribution: Type locality, not specifically given by Rafinesque, but Vanatta gives "Kentucky River."

According to Simpson (1900), this species has the following range: "Entire Mississippi-drainage; St. Lawrence and its tributaries; Alabama River system; southeast into Florida; southwest to Guadeloupe River, Texas." However, this includes several varieties.

Typical *E. dilatatus* is certainly found in western New York, occurs in the Kanawha system up to the Bluestone River in West Virginia, and in New River to Virginia (See Call, 1885, and Carnegie Museum). In the Tennessee it extends to northern Alabama, and in the headwaters to southwestern Virginia. Northward it is found in Canada, Michigan, Wisconsin, and Minnesota. Westward it extends to Iowa, Kansas, Oklahoma, and northern Louisiana. In the Alabama system and in southern Arkansas it is largely represented by the form *subgibbosus* (Lea) (See Lewis, 1877). But some specimens from the Cahaba, Black Warrior, and Tombigbee-drainages in the Carnegie Museum, represent the typical phase, while specimens from the Coosa are all *subgibbosus*. Likewise in Arkansas the two forms seem to pass into each other (See Wheeler, 1918).

E. dilatatus passes over into the drainage of Lake Michigan and Lake Erie, but, as we shall see below, in Lake Erie proper, it assumes a peculiar form, which is entitled to subspecific rank. In the tributaries of the lake, the typical form is always present.

In western New York, it has been reported from the St. Lawrence-drainage as

well as from the Erie Canal and the Mohawk River (Call) and it belongs to the few species, which have gone along this route probably in very recent times. Whether this stock came from Lake Erie or from the upper Allegheny, remains to be seen.

Elliptio dilatatus sterkii Grier (1918).

Unio gibbosus Barnes (Sterki, 1907*a*, p. 392) small form; *Unio gibbosus* Barnes (Ortmann, 1909*b*, p. 203) lake form; *Unio gibbosus* Barnes (Walker, 1913, p. 22, map, fig. 2 on p. 30); *Elliptio dilatatus sterkii* Grier, 1918, p. 9.

Plate VIII, fig. 3.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 203 (as form of *Unio gibbosus* from Lake Erie).
Grier, 1918, p. 9.

Characters of variety: Distinguished from typical *E. dilatatus* by small size, rather swollen shell, (with the diameter over thirty percent, while it is less in the typical form), the more anterior position of the beaks, and lighter color of the epidermis, which is from yellowish olive to brown (sometimes dark brown), with more distinct rays (chiefly when young). Generally in old shells the posterior slope or the posterior end of the shell is lighter in color (yellowish to rusty brown). The growth-rests are rather regular, and rather well-marked by concentric dark bands. Nacre mostly lighter, white to light purple, but sometimes as dark as in the typical form.

				L.	H.	D.	Pr.ct.
Size: 1.	Erie, Cat. No. 61.3228 (largest)			87 mm.	45 mm.	33 mm.	.38
2.	Erie, Cat. No. 61.4628	(♂)	type set	86 "	40 "	33 "	.38
3.	do.	do.	(♀) do.	77 "	37 "	27 "	.35
4.	do.	do.	(♀) do.	72 "	33 "	23 "	.32
5.	do.	do.	(♂) do.	58 "	29 "	18 "	.31

Soft parts: They agree entirely with those of typical *dilatatus*. *Glochidia* not known.

Breeding season: Gravid females (with eggs) have been observed on July 8 and 12, 1910.

Remarks: With a rather large number of specimens (over fifty) before me, I am convinced that this is, as Grier has pointed out, a good local race of *E. dilatatus*. Although the normal form locally does not grow very large, the lake-form is always more swollen (see measurements), and this gives to the shell a rather subcylindrical shape, chiefly so in its anterior part. In the color of the epidermis, young specimens of *sterkii* are distinctly lighter than normal *dilatatus*, and in consequence of

this, the rays are better visible, and the growth-rests become more marked. When older the epidermis becomes darker, and may be even blackish, but in many old specimens it remains light, chiefly so at or near the posterior end. This part of the shell is often covered with a growth of other organisms. The regularity of the growth-rests is rather variable, but in well-developed specimens it is quite striking. In shape young specimens are more like normal *dilatatus*. In fact sometimes they are indistinguishable except by the color.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania (type locality).

Lake Erie, off North shore of Presque Isle, Erie, Erie Co., Pennsylvania (depth 10 feet).

Lake Erie, Cedar Point, Erie Co., Ohio (C. Brookover); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Port Colborne, Welland Co., Ontario, Canada (C. Goodrich).

Distribution and Ecology (See fig. 10 and Walker, 1913, fig. 2, p. 30): *Type locality:* Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania. *Type set:* Carnegie Museum Cat. No. 61.4628 (not 4268, as Grier states!).

This form is exclusively known from Lake Erie. According to my observations it lives in Presque Isle Bay, preferably along the North shore of the bay, in the characteristic fine sand, in from one to five feet of water, and chiefly at the edge or within the *Juncus americanus* formation (among "rushes"). It also is frequently found among *Chara* patches. However, I also found it on the south shore of the bay in gravel and shingle, and one specimen was obtained by the "sand-sucker" in the open lake, in about ten feet of water.

Sterki (1907*a*, p. 392) and Walker (1913, p. 22) are the only authors, who previously have mentioned this form from Lake Erie, but without separating it from the main form. Grier (1918) first recognized it as a variety.

Note: It is interesting to compare specimens obtained under similar ecological conditions at other localities. A very remarkable form is *E. dilatatus* from Chautauqua Lake, Chautauqua Co., New York. I have eighteen specimens collected by various parties at Bemus Point and Celeron. This is a form distinctly inclining towards the var. *sterkii*. It is rather small (longest 79 mm.), is also slightly more swollen than the true *dilatatus*, and has the beaks a little more anterior; but with regard to color, the Chautauqua form does not differ from *dilatatus*. This is, of course, no intergrade (genetically), but has developed independently, coming up into Lake Chautauqua from the upper Allegheny.

In Conneaut Lake, Crawford Co., Pennsylvania, a form of *E. dilatatus* exists, which is not at all different from the normal one, except that it is rather small. It is rare in this lake, but more abundant in the outlet, and assumes, in French Creek, to which the outlet flows, the typical size.

The only tributary of Lake Erie in Pennsylvania, Conneaut Creek, contains a small race of typical *E. dilatatus*. There are no indications, that this has come up from the lake. It may as well have crossed over from the Beaver or French Creek drainages.

Of course *E. dilatatus sterkii* must have come into the lake from the Ohio system, and the Wabash-Maumee route is the first to be considered (See Walker, 1913), but it may have crossed elsewhere, since the typical form ascends in many places far into the headwaters. The remarkable thing is that in all tributaries of the lake the normal *dilatatus* is present, in Michigan at Ann Arbor), Marshall, 1895) in Ohio in the Cuyahoga (Dean, 1890) in Indiana in the drainage of the Maumee, St. Marys, and St. Josephs Rivers (Call, 1900). Call mentions the fact that there is in the lakes of northern Indiana, a form which is flatter and thinner. This, of course, would not lead to *sterkii*.

Elliptio violaceus (Spengler) (1793).

Unio violaceus Spengler. Haas, 1913, p. 54, text-fig. 2; *Unio complanatus* (Dillwyn) Simpson, 1914, p. 651.

Plate VIII, figs. 4, 5.

Records from Pennsylvania:

Say, 1817 (Delaware and Schuylkill Rivers) as *purpureus* (See Binney, 1858).
Haldeman, 1844 (Lancaster Co.).
Lea, Obs. IV, 1848 (Cobbs Creek, La Grange, near Philadelphia) (*fuliginosus*).[66]
Gabb, 1861 (League Island and Schuylkill River, Philadelphia).
Bruckhart, 1869 (Lancaster Co.).
Hartman & Michener, 1874 (Chester Co.).
Schick, 1895 (Delaware and Schuylkill Rivers, Corinthian Reservoir, Philadelphia; Canal at Manayunk, Philadelphia Co.; Munckinipattus Creek, Glenolden, Delaware Co.).
Ortmann, 1909*b*, p. 208.
Caffrey, 1911 (Lehigh and Delaware Rivers, Northampton Co.).

Characters of the shell: Shell moderately large and moderately heavy. Outline subtrapezoidal, more or less elongate, generally almost twice as long as high, or even longer. Anterior end rounded, posterior end slightly produced and slightly pointed; lower margin more or less convex, often nearly straight. Upper margin subparallel to the lower margin, forming an angle with the obliquely descending posterior margin. Beaks not prominent, at variable distance from the anterior end, but not close to it. Beak-sculpture distinct, consisting of five to six ridges, the first two or three curved and subconcentric, those following running in the

[66] Cobbs Creek is a branch of Darby Creek, near Essington, Philadelphia County.

direction of the growth-lines, being subparallel and nearly straight in the middle, and curving up in front and behind, the posterior curve being angular, with a slight swelling (See Marshall, 1890, fig. 6). Shell not, or very little, swollen, generally more or less compressed, chiefly so on the posterior slope, with a blunt, more or less distinct posterior ridge. Sides of the disk generally flat. Surface without sculpture.

Epidermis yellowish, to brown and blackish. In young specimens, more or less distinct greenish rays are present. The epidermis rarely is lighter and greenish in color, with more distinct rays. The latter are capillary or somewhat broader, straight. In older shells, all traces of rays generally disappear. Growth-rests more or less strongly marked, but often quite indistinct.

Hinge-teeth well-developed, but not very heavy. Pseudocardinals divergent, ragged. Interdentum practically absent. Lateral teeth long, gently curved. Beak-cavity very shallow. Dorsal muscle-scars in the beak-cavity. Nacre white or colored, with an immense range of variation, through all shades of salmon, pink, red, purple, and blueish, with coppery or bronze lustre or iridescence; often whitish with lurid tints (greenish and grayish, as if discolored).

No sexual differences in the shell.

	L.	H.	D.
Size: 1. Flinton, Cat. No. 61.3797 (largest from Pennsylvania)	120 mm.	65 mm.	32 mm.
2. Tioga, Cat. No. 61.4312	110 "	57 "	25 "
3. Selinsgrove, Cat. No. 61.4643	100 "	58 "	35 "
4. Manayunk, Cat. No. 61.1832	88 "	47 "	27 "

Soft parts (See Ortmann, 1912, p. 269). *Glochidia: ibid.,* Pl. 19, fig. 1.

Breeding season: For gravid females the following dates are at hand: April 26, 1909; May 3, 1909; May 4, 1909; May 6, 1912; May 9, 1911; May 10, 1912; May 11, 1912; June 3, 1912; June 4, 1912; June 5, 1912; June 7, 1912; June 10, 1912; June 12, 1912; June 13, 1912; June 14, 1910; July 9, 1914; July 11, 1914; July 16, 1908. Glochidia have been found as early as June 7, and discharging females have been observed on June 7 and 13, and July 9 and 11. According to these dates this is a tachytictic form, breeding from the end of April to July, but the season may extend to August, as Conner (1907, p. 88) states. The discharging females expelled their placentæ whole into the surrounding water.

Remarks: This species is quite characteristic and easily recognized, in spite of its immense range of variation. The trapezoidal outline (with the upper and posterior margins forming an angle), and the flat sides of the shell are reliable features, and in most cases the shell is distinctly compressed. If more swollen,

the greatest width is situated in the region of the posterior ridge, but not in the anterior part of the shell, as in *E. dilatatus*. This anterior swelling, and the tapering posterior end of the shell, distinguish this latter species from *E. violaceus*.

In other respects *E. violaceus* is extremely variable. First of all in size and shape (longer or shorter), then in the degree of compression (compare our measurements). Furthermore the color of the outside and of the nacre is variable, and finally the epidermis may be more or less smooth, or may be roughened by concentric lamellæ. Since the shell is not very particular as to station (see below), it is not astonishing that the responses to the environment are numerous, and that it assumes in many places peculiar features, which, however, are not at all constant, and may turn up anywhere under proper conditions, and are connected by innumerable intergrades. There is no tendency in Pennsylvania to develop local races or varieties, and I am perfectly satisfied that there is only *one* species in our region.

"Species-making" within this form has gone beyond all bounds, and in a large number of Lea's "species," chiefly from the southern states, the question may be raised whether Lea was actually in earnest, when proposing them, or whether he only wanted to mystify contemporaneous and subsequent students of naiadology. Great credit is due to Simpson for straightening out the worst of this tangle; but I think that Simpson has not gone far enough. I shall mention here a few additional instances of species created by Lea, which in my opinion simply fall as synonyms under *E. violaceus*, merely representing individual phases. This chiefly concerns such forms as are actually found in our state.

Unio complanatus jejunus (Lea): Simpson (1914, p. 658) unites *jejunus* and *percoarctatus* Lea, and makes this a variety of the present species. Both are southern types (from the Carolinas), and both are said to be more compressed, while *jejunus* is reported to have an inclination to be biangulate behind, and *percoarctatus* is said to have the surface covered with loose concentric striæ. All these characters are found in the Pennsylvanian *E. violaceus* in certain individuals. They may be very much compressed, they have very often a tendency to be biangulate behind, and they have often a rough epidermis, with loose striæ. I have specimens, which completely agree with *jejunus*, as well as with *percoarctatus*, and sometimes such specimens (See Plate VIII, fig. 5) prevail at certain localities, but they are always connected with the normal form by intergrades.

Unio roanokensis Lea, and *northamptonensis* Lea: Simpson (1914, p. 666) regards these as one species, distinct from our species. The form *northamptonensis* is reported from as far north as Massachusetts, and might be expected in Penn-

sylvania. Both shells are described as being large, flat, biangulate behind, while *northamptonensis* is said (Simpson, 1900, p. 728 *footnote*) to have in addition the posterior point elevated above the base line. Such shells may be found anywhere in Pennsylvania. Specimens from Hartford, Connecticut, one of the type localities of *northamptonensis*, and which are in the Carnegie Museum, are in fact normal, large representatives of *E. violaceus*.

Unio fuliginosus Lea. This shell from Cobbs Creek, near Philadelphia, is quoted twice by Simpson in 1900, first (p. 722) as synonym of *complanatus*, then

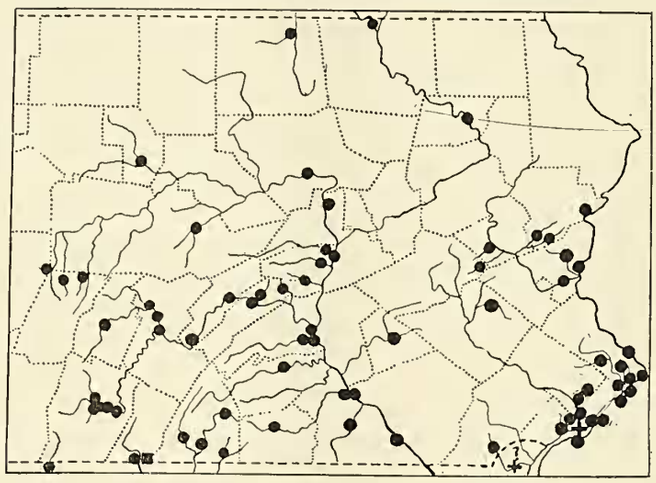


Fig. 11.

● *Elliptis violaceus.*
■ *Elliptis cupreus.*
+ *Elliptis fisherianus.*

(p. 727) as of *icterinus* Conrad; but in 1914 (p. 665) only the latter reference is given. I do not know *icterinus*, which is southern. The *fuliginosus* Lea, however, does not agree with the original description of *icterinus* (Conrad, Mon. 4, 1836, Pl. 18, fig. 2), and I think, the first reference of Simpson is correct, and the Pennsylvanian *fuliginosus* is identical with *E. violaceus*.

Localities in Pennsylvania represented in the Carnegie Museum:

Delaware-drainage:

Delaware River, Penns Manor and Yardley, Bucks Co.; Shawnee, Monroe Co.
White Clay Creek, Avondale, Chester Co.
Schuylkill Canal, Manayunk, Philadelphia Co.
Wissahickon Creek, Flourtown, Montgomery Co. (P. A. Keppelmann).
Little Neshaminy Creek, Grenoble, Bucks Co.
Common Creek, Tullytown, Bucks Co.
Princess Creek, Kunkletown, Monroe Co.

Meniolagomeka Creek, Smith Gap, Monroe Co.
Lizard Creek, Mantz and West Penn, Schuylkill Co.
Mahoning Creek, Lehighton, Carbon Co.

Susquehanna-drainage:

Susquehanna River, York Furnace and York Haven, York Co.; Duncannon, Perry Co.; Selinsgrove, Snyder Co.
Codorus Creek, York, York Co.
Conewago Creek, York Haven, York Co.; Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co.
Shermans Creek, Duncannon, Perry Co.
Juniata River, Juniata Bridge, Perry Co.; Lewistown, Mifflin Co.
Canal, Mifflintown, Juniata Co. (D. A. Atkinson).
Lost Creek, Mifflintown, Juniata Co. (D. A. Atkinson).
Cocolamus Creek, Cocolamus, Juniata Co. (D. A. Atkinson).
Raystown Branch Juniata River, Ardenheim, Huntingdon Co.; Everett and Mount Dallas, Bedford Co.; Lutzville, Bedford Co. (J. F. L. Raschen); Dunning Creek, Bedford, Bedford Co. (J. F. L. Raschen); Shobers Run, Bedford Springs, Bedford Co. (A. Koenig).
Frankstown Branch Juniata River, Huntingdon and Alexandria, Huntingdon Co. (D. A. Atkinson); Hollidaysburg, Blair Co.
West Branch Mahantango Creek, Richfield, Juniata Co. (D. A. Atkinson).
Middle Creek, Freeburg, Snyder Co. (D. A. Atkinson).
Penns Creek, Selinsgrove, Snyder Co.
Canal, Watsontown, Northumberland Co. (D. A. Atkinson).
West Branch Susquehanna River, Williamsport, Lycoming Co. (D. A. Atkinson).
Bald Eagle Creek, Milesburg, Center Co.
Driftwood Branch Sinnamahoning Creek, Driftwood, Cameron Co.
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson).
Chest Creek, Patton, Cambria Co.
Cush Cushion Creek, Green Township, Indiana Co. (D. A. Atkinson).
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.
Millrace of Crooked Creek, Tioga, Tioga Co.

Potomac-drainage:

East Branch Little Antietam Creek, Waynesboro, Franklin Co.
Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

Sacony Creek, Kutztown, Berks Co. (H. K. Deisher).
Big Neshaminy Creek, "Edderton,"[67] Bucks Co. (H. W. Fowler).
"Guinea Creek,"[68] Woodbourne, Bucks Co. (H. W. Fowler).

[67] Probably *Eddington.*

[68] No creek of this name occurs on the map of the U. S. Topographic Survey (Sheet Burlington). The creek at Woodbourne is a branch of Mill Creek.

Bushkill Creek, Belfast, Northampton Co. (H. W. Fowler).
Susquehanna River, York Furnace, York Co. (W. Stone).
Little Swatara Creek, Jonestown, Lebanon Co. (W. H. Zehring) (C. H. Conner).
Juniata River, Newton-Hamilton, Mifflin Co. (H. T. Mather, Jr.).

Localities on the New Jersey side of the Delaware in the Philadelphia Academy of Natural Sciences:

Delaware River, Washington Park, near Newbold, Gloucester Co. (C. H. Conner); Delanco, Burlington Co. (H. A. Pilsbry); Burlington Island, Burlington Co. (H. W. Fowler).

Other localities represented in the Carnegie Museum: [69]

St. Lawrence-drainage:

Spider Bay of Georgian Bay, Sans Souci, Parry Sound Co., Ontario, Canada (H. Kahl).
Muskoka Lake, Bala, Muskoka Co., Ontario, Canada (A. S. Daggette).
Severn River, Gloucester Pool, Muskoka Co., Ontario, Canada (O. A. Peterson).
Pigeon Lake, Bobcaygeon, Victoria Co., Ontario, Canada (G. H. Clapp).
Sandy Lake, Peterboro Co., Ontario, Canada (G. H. Clapp).
St. Lawrence River, Montreal, Quebec, Canada (Hartman collection); Bluff Island and Grindstone Island, near Clayton, Jefferson Co., New York (Miss A. H. Robinson) (H. Kahl).
Lake Ontario, Hamilton Bay, Wentworth Co., Ontario, Canada (Miss R. Buchert); Braddock Bay, Manitou Beach, Monroe Co., and Sodus Point, Wayne Co., New York (R. H. Santens).
Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Lake Champlain, New York (Hartman collection).

New England:

Fish River, Eagle Lake, Square Lake, and Cross Lake, Aroostook Co., Maine (O. O. Nylander).
Little Madawaska River, Westmoreland, Aroostook Co., Maine (O. O. Nylander).
Piscataquis Co., Maine (C. Goodrich, donor).
Otisfield, Cumberland Co., Maine (G. H. Clapp, donor).
Lilly Lake, Pittsfield, Merrimack Co., New Hampshire (Mrs. L. D. Thompson, donor).
Shawsheen River, Bedford, Middlesex Co., Massachusetts (Mrs. L. D. Thompson).
Haughtons Pond, Blue Hills, Norfolk Co., Massachusetts (Mrs. L. D. Thompson, donor).
Connecticut River, Hartford, Hartford Co., Connecticut (Hartman collection).

New York and New Jersey:

North Branch Susquehanna River, Binghamton, Broome Co., New York (H. H. Smith).
Culvers Pond, Sussex Co., New Jersey (J. F. L. Raschen).
Stony Brook and Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Delaware River, Fish House, Camden Co., New Jersey.

[69] Only those are given for which I either can vouch personally, or which are from reliable sources. The Carnegie Museum possesses many more, chiefly from the southern states, which may be correct or wrong, and which are referred to various species of Lea, which cannot properly be identified at present. Specimens from Catawba River, Bridgewater, Burke Co., North Carolina, collected by myself, correspond well with *U. percoarctatus* Lea, which is from the same river in Gaston Co. a little lower down. No typical *E. violaceus* was met with here, but associated with it is a form appearing quite distinct, but which I have been unable to identify. Walker, to whom I have sent specimens, did not wish to express an opinion in regard to them.

Barton Run, below Tomlisons Mill (= Jennings Mill), Marlton, Burlington Co., New Jersey (C. H. Conner).[70]

Potomac-drainage:

Potomac River, Cabin John, Montgomery Co., Maryland (J. D. Haseman); Hancock, Washington Co., Maryland; Cherry Run, Morgan Co., West Virginia.
Wills Creek, Ellerslie, Allegheny Co., Maryland.
South Branch Potomac River, Southbranch and Romney, Hampshire Co., West Virginia.
Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
North Fork Shenandoah River, Broadway, Rockingham Co., Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.
South River, Waynesboro, Augusta Co., Virginia.

Southern localities:

Rappahannock River and Marsh Run, Remington, Fauquier Co., Virginia.
Mountain Run, Culpeper, Culpeper Co., Virginia.
Rapidan River, Rapidan, Culpeper Co., Virginia.
North River, Lexington, Rockbridge Co., Virginia.
Calf Pasture River, Goshen, Rockbridge Co., Virginia.
Jackson River, Covington, Allegheny Co., Virginia.
Roanoke River, Salem, Roanoke Co., Virginia.
Tinker Creek, Roanoke, Roanoke Co., Virginia.
Mason Creek, Salem, Roanoke Co., Virginia.

Distribution and Ecology in Pennsylvania (See fig. 11): This is the commonest form of Naiades in the Atlantic-drainage in Pennsylvania, and is as characteristic and as abundant on the eastern side of the Alleghenian divide, as is *E. dilatatus* on the western, in fact, it is even more universally distributed than the latter. (Ortmann, 1913*a*, pp. 361, 362). It apparently has no ecological preferences, being found practically in any permanent body of water; in canals and reservoirs with quiet water and muddy bottom, as well as in large rivers with strong current and heavy gravel and rocks. In the small creeks it goes up very far into the headwaters, and is found, for instance, in the small tributaries of the West Branch of the Susquehanna, close to the divide as in Cush Cushion Creek in Indiana County. Here it is only about twenty miles away from the nearest locality of *E. dilatatus* in the Allegheny-drainage in Indiana County. (Yellow and Little Mahoning Creeks.) Also in Virginia, similar observations have been made (See Ortmann, 1913*a*). In the region, where the headwaters of New River and those of the James and Roanoke Rivers come together, the two species are found immediately west and east of the divide.

The ability of *E. violaceus* to live everywhere under a great variety of environmental conditions undoubtedly accounts for its great variability, as well as its

[70] Quite a peculiar form, unusually swollen, with white nacre, which requires further investigation.

tendency to develop many different phases, which may turn up anywhere under proper conditions, but which do not lead to the development of geographical races, at least in our territory.

General distribution: Type locality, North America (Spengler).

According to Simpson (1900, p. 725), *E. violaceus* is found on the Atlantic side from the St. Lawrence to Georgia. The southern boundary is extremely uncertain, and is obscured by a great development of local forms, the standing of which is very doubtful.[71] Northward, it goes to Maine (Jackson, 1908, Lermond, 1909, Nylander, 1914), and, according to Call, to Nova Scotia. From the lower St. Lawrence-drainage, it has been reported from many localities in Vermont, New York, and Canada, up to and into Lake Ontario. It has never been found in Lake Erie, but turns up again in the upper lakes district, in western Ontario (see our localities in Sandy and Pigeon Lakes, and in Muskoka and Parry Sound Cos.). It has been discovered in various places in northern Michigan, as far as Lake Superior (See Walker, 1898, p. 5; 1913, map on p. 30, and Winslow, 1917, p. 11). An isolated locality is the one reported by Sterki (1907*a*, p. 393) from a mill-race at New Philadelphia, Tuscarawas Co., Ohio, and recently I found a single specimen in Grand River, Eagleville, Ashtabula Co., Ohio.

This westward extension of the range apparently was not by way of Lake Erie, but from the lower St. Lawrence, in the region about Ottawa, in the direct line toward Lake Huron, so that in Michigan it is a recent immigrant from the North. Walker (1913) has treated this question in detail: the migration was by way of the Trent or Nipissing route (*l. c.*, pp. 44, 45, fig. 4).

The established range of this species is unique, and larger than that of any other form of the Atlantic slope. Most peculiar is the westward extension in the north. There is only one species, which might be compared with this, *Eurynia nasuta*, but the range of this from west to east goes by way of Lake Erie, and is undoubtedly governed by different laws, as I have shown (Ortmann, 1913*a*, pp. 378 ff.).

ELLIPTIO CUPREUS (Rafinesque) (1820).

Unio productus CONRAD. SIMPSON, 1914, p. 690.[72]

Plate VIII, fig. 6.

Records from Pennsylvania:

Ortmann, 1910, p. 117 (Fulton Co.).

[71] Conrad (1834, p. 8) says that the shells of the type of *U. purpureus* (= *E. violaceus*) are in the Savannah, Oconee, and Ocmulgee Rivers, and also in Flint River, Georgia, but that to the west of this he did not find them.

[72] *U. fisherianus* Reeve (1865, Pl. 24, fig. 113) is not *U. fisherianus* of Lea, but clearly the present species.

Characters of the shell: Shell rather small and not heavy. Outline elongated trapezoidal, or elongated ovate, lance-head shaped, a little over twice as long as high. Greatest height of the shell about in the middle at the ligament (mostly height of shell about the same from the beaks to the end of the ligament). Anterior end rounded, posterior end tapering and bluntly pointed. Lower margin more or less curved, but often almost straight in the middle. Upper margin straight or somewhat curved, nearly parallel to the lower margin, and forming a more or less distinct angle with the upper posterior margin. Beaks not prominent, placed rather anteriorly, but at a certain distance from the anterior end. Beak-sculpture identical with that of *E. violaceus*, but sometimes the straight portion of the bars, in their middle part, is slightly and indistinctly sinuated. Shell not swollen, more or less compressed, with the sides of the disk rather flat. A rounded, indistinct posterior ridge is present. Surface without sculpture.

Epidermis greenish olive, brownish olive, yellowish brown to brown, or even blackish. Young specimens sometimes with rather indistinct, greenish rays, of the same character as those of *E. violaceus*, but in most cases no traces of rays are visible. Growth-rests generally not marked off by darker color.

Hinge-teeth well-developed, but not very strong, of the general character of those of *E. violaceus*. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre whitish, lurid, or of some shade of red or purple, lighter or darker, often with coppery iridescence.

No sexual differences in the shell.

		L.	H.	D.
Size: 1.	Romney, Cat. No. 61.5898 (extralimital)	88 mm.	38 mm.	23 mm.
2.	Fulton Co., Cat. No. 61.4323 (largest from Pa.)	70 "	30 "	15 "
3.	do. do.	66 "	30 "	16 "
4.	do. do.	60 "	27 "	16 "
5.	do. do.	49 "	23 "	11 "

Soft parts (See Ortmann, 1912, p. 270). Gravid females have subsequently been found, and the structure of the marsupium agrees fully with that of *E. violaceus*. *Glochidia:* L. 0.20, H. 0.20 mm., similar in shape to those of *E. violaceus* (which are 0.20 × 0.19 mm.).

Breeding season: Gravid females were found on May 6, 1912; June 3, 1912; June 4, 1912; June 7, 1912; June 8, 1912. All these were from the Potomac, Rappahannock, and James drainages, outside of Pennsylvania. At the earliest date, glochidia in some individuals were already present.

Remarks: Obliquaria cuprea Rafinesque (1820, p. 304) is this species, as is evident from the description, the very poor (exaggerated) figure, and the comparison

with *U. nasuta* Say. Rafinesque gives the Monongahela and Potomac Rivers as habitats, but the first locality apparently is an error. (On p. 294 Rafinesque describes a *Unio fasciata cuprea*, but this does not conflict with *Obliquaria cuprea*).

This species is allied to the type of *E. violaceus*, but differs in its extreme elongation and lanceolate shape. The subtrapezoidal outline is obscured, but at least in young specimens is indicated by the presence of an angle between the upper and the posterior margins. It is hardly possible to confuse this species with *E. violaceus*, but it has a much closer resemblance to the following (*E. fisherianus*), and has been mixed up with this by various writers. It is possible that *E. fisherianus* is merely a variety of *E. cupreus*. There are other "species" in the southern states, which group with this form, but they require further study.

This shell (as well as *E. fisherianus*) has an outward resemblance to *Eurynia nasuta* (Say), and was supposed to be nearly allied to it by the earlier authors, but the anatomical structure is entirely different.

Localities represented in the Carnegie Museum:

Great Tonoloway Creek, Thompson Township, Fulton Co., Pennsylvania.
Potomac River, Hancock, Washington Co., Maryland.
South Branch Potomac River, Southbranch and Romney, Hampshire Co., West Virginia.
Rappahannock River, Virginia (G. H. Clapp, donor).
Marsh Run, Remington, Fauquier Co., Virginia.
Mountain Run, Culpeper, Culpeper Co., Virginia.
North River, Buena Vista and Lexington, Rockbridge Co., Virginia.
Calf Pasture River, Goshen, Rockbridge Co., Virginia.
Jackson River, Covington, Alleghany Co., Virginia.

Locality represented in the Philadelphia Academy of Natural Sciences:

Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia (G. W. Tryon, Jr.).

Distribution and Ecology (See fig. 11): *Type-locality*, Potomac River (Rafinesque).

Conrad's *Unio productus*, which undoubtedly is this species, is given from the Savannah River, Augusta, Richmond Co., Georgia. But Simpson (1900, p. 735) mentions only North Carolina, Virginia, and Maryland. But later (1914, p. 691) he adds the type-locality. The southward range of this species as yet remains obscure, and furthermore very few exact localities are on record. Besides those given by myself, I know of only one which is reliable, that furnished by Pilsbry (1894) from Sideling Creek, Allegany Co., Maryland.[73]

[73] As I have suggested elsewhere (Ortmann, 1913*a*, p. 320), Conrad's *Unio lanceolatus* (1846) from the Upper James-drainage, is probably this species.

I have located this species in the drainages of the Potomac, Rappahannock, and James, in Maryland, Virginia, and eastern West Virginia, and also in a northern tributary of the Potomac (Great Tonoloway Creek) in southern Pennsylvania, just North of the Mason and Dixon line. I have hunted for this species in other tributaries of the Potomac in Pennsylvania, in Antietam and Conococheague Creeks, but failed to find the slightest trace of it.

Where I collected this form, it is not at all rare. I found it either in gravel, or among larger rocks, in mud-filled interstices, but generally not in strong current, but in quiet coves and eddies. It also seems to prefer the smaller streams to the larger rivers.

With the exception of the Rappahannock, I never found it East of the Blue Ridge, on the Piedmont Plateau or Coastal Plain, but it should be expected to be more frequent there. The relation of its distribution to that of the next species (*E. fisherianus*) should be ascertained.

Elliptio fisherianus (Lea) (1838).

Unio fisherianus Lea. Simpson, 1914, p. 692.

Plate VIII, fig. 7.

Records from Pennsylvania:

Gabb, 1861 (Schuylkill River, above Girard Bridge, Philadelphia).
? Hartman & Michener, 1874 (White Clay Creek, Chester Co.) (see below).

Characters of the shell: Very close to *E. cupreus*, and differing chiefly by somewhat larger size, slightly more elongated shape, and greater taper in the posterior part of the shell. The greatest height of the shell is situated more anteriorly, at about the beaks, and from this part the shell decreases in height to the posterior end. At the same time the posterior end is more elevated, so that the posterior ridge is not straight, but curves up slightly behind, and the lower margin also is more curved. In all other characters this form agrees with *E. cupreus*. The epidermis is more greenish blackish, the nacre white to purple.

			L.	H.	D.
Size: 1.	Kent Co., Del., Cat. No. 61.4645		106 mm.	40 mm.	26 mm.
2.	do.	do.	88 "	35 "	23 "
3.	do.	do.	73 "	27 "	19 "
4.	do.	do.	57 "	22 "	14 "

Soft parts, glochidia, and *breeding season* unknown.

Remarks: According to the material at hand, this species stands very close to *E. cupreus*, and it possibly is only a local race (lowland form) of it. However

intergrades have not been observed, but may exist in the lower parts of the rivers. Attention should be paid to this question.

Localities represented in the Carnegie Museum:

Mill-pond of Ratcliff Creek, Chestertown, Kent Co., Maryland (E. G. Vanatta).
Choptank Mills, Kent Co., Delaware (S. N. Rhoads).

Localities represented in the Philadelphia Academy of Natural Sciences:

Church Hill, Queen Anne Co., Maryland (E. G. Vanatta).
Potomac River, Washington, D. C. (G. W. Tryon, Jr.) (John Ford).

Distribution and Ecology (See fig. 11): *Type locality,* Head of Chester River, Maryland (Lea).

Simpson reports this species from: "Virginia, Maryland, Pennsylvania," and Rhoads (1904) from two localities in Delaware.[74] There is no doubt that "Pennsylvania" is founded upon the records mentioned above (Gabb, and Hartman & Michener). Gabb reports only a single specimen from his locality, the lower Schuylkill River, and since this evidently offers the necessary conditions, there is no reason to doubt the fact that the species has occurred there. However, I entertain strong doubts that this species ever existed in White Clay Creek in Pennsylvania. I have been at White Clay Creek, at Avondale, Chester Co., Pennsylvania, and here it is an upland stream, and does not at all present the conditions, which I regard as being favorable for this species. It is possible that Hartman & Michener found this species farther down in this creek, in the lowlands of the state of Delaware, but not in Pennsylvania.[75]

The evidence for the existence of this species in Pennsylvania rests upon the single individual reported by Gabb. It is not impossible that it may be found again, and the chance to rediscover it will be in or near the estuary of the Delaware, for according to the records at hand this species seems to prefer the Coastal Plain, living in slowly running rivers, ponds, or similar stations; it is a lowland form, as I have pointed out elsewhere (Ortmann, 1913*a*, p. 361).

Subfamily ANODONTINÆ (Swainson) Ortmann (1910).

Ortmann, 1910, p. 117; 1911*b*, p. 336; 1912, p. 224.

Key to the Genera of the Anodontinæ.

a_1. Beak-sculpture double-looped, with a sharp reëntering angle or a sinuation. Mantle connection between anal and supra-anal openings moderate or very long. No tendency to unite the inner lamina of the inner gills with abdominal sac.

[74] In addition to the above locality: Seaford, Sussex Co., Delaware.

[75] The Carnegie Museum acquired in the Hartman collection a single set of this species, but there is no indication that it came from our state.

b_1. Hinge-teeth more or less well-developed, at least the pseudoeardinals present. Shell generally not very thin..... *Lasmigona.*

b_2. Hinge-teeth completely absent. Shell thin, generally very thin..... *Anodonta.*

a_2. Beak-sculpture eoneentrie. Mantle connection between anal and supra-anal openings moderate. Sometimes a tendeney to unite the inner lamina of the inner gills with the abdominal sae.

b_1. Beak-seulpture fine. Hinge-teeth practically absent..... *Anodontoides.*

b_2. Beak-sculpture heavy, often very heavy. Hinge-teeth more or less developed or rudimentary.

c_1. Hinge complete, or at least the pseudoeardinals present. Marsupium with simple ovisaes. *Alasmidonta.*

c_2. Hinge-teeth rudimentary, but slight traces of pseudoeardinals present. Marsupium with the ovisaes subdivided into transverse eompartments..... *Strophitus.*

Genus Lasmigona Rafinesque (1831).

Symphynota Ortmann, 1912, p. 280; *Symphynota,* Simpson, 1914, p. 480; *Lasmigona* Frierson, 1914*b*, p. 40.

Type *Alasmidonta costata* Rafinesque.

Simpson has divided this genus into three subgenera, and Ortmann (1914, p. 41) has added others, but the latter are extralimital. The nomenclature of the genus and the subgenera has been revised in this paper in accordance with Frierson (1914*b*, p. 40) and Walker (1918).

Key to the Subgenera of Lasmigona.

a_1. Lateral hinge-teeth present. Shell smooth. Beak-seulpture double-looped. Hermaphroditie. Subgenus *Platynaias.*

a_2. Lateral hinge-teeth obliterated. Shell smooth, or with ribs upon the posterior slope. Gonoehoristic.

b_1. Shell subrhomboidal or subelongate. Posterior slope with ribs. Beak-seulpture indistinctly double-looped..... Subgenus *Lasmigona.*

b_2. Shell broadly ovate-rhomboidal, not elongated, with high posterior wing. Posterior slope with ribs, which may be obliterated. Beak-seulpture sharply double-looped... Subgenus *Pterosyna.*

Subgenus Platynaias Walker (1918).

Symphynota Simpson, 1914, p. 481; Ortmann, 1914, p. 42; *Platynaias* Walker, 1918, p. 2.

Type *Unio viridis* Rafinesque.

Two species belong to this subgenus, which may be distinguished as follows.

Key to the Species of the Subgenus Platynaias.

a_1. Shell moderately large, subsolid, eompressed. Outline more or less rhomboidal; western habitat. *L. (P.) viridis.*

a_2. Shell small, thin, not so much eompressed. Outline rather subovate; eastern habitat. *L. (P.) subviridis.*

Lasmigona (Platynaias) viridis (Rafinesque) (1820).

Symphynota compressa Lea. Simpson, 1914, p. 481; *Lasmigona viridis* (Rafinesque) Frierson, 1915, p. 59.

Plate IX, figs. 1, 2.

Records from Pennsylvania:

Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 196, 202.

Characters of the shell: Moderately large, subsolid, but not very heavy. Outline subrhomboidal, or subtrapezoidal, longer than high. Anterior end rounded, posterior subtruncate. Lower margin slightly convex; upper margin straight, more or less ascending and elevated posteriorly, forming a more or less distinct wing at the upper posterior angle. In young shells the upper posterior margin is symphynote. Beaks not prominent, placed in front of the middle of the shell. Beak-sculpture distinct, consisting of about five bars, of which the first or the two first are subconcentric, while those following are distinctly double-looped, with the anterior loop rounded, the posterior angular, and slightly narrower than the anterior, a sharp re-entering sinus between them. Sometimes the last bars are somewhat irregular, interrupted or wavy in their anterior part, but this feature is variable and often absent (compare Marshall's figure, 1890, fig. 1). Shell rather flat and compressed, disk only slightly convex. An indistinct, blunt posterior ridge is present. Greatest diameter of the shell at, or immediately in front of, this ridge. Behind the ridge the posterior slope appears more or less compressed and winged. Surface without sculpture.

Epidermis yellowish to greenish, or, when old, blackish, with more or less distinct green to blackish rays, which are straight, narrow or broad, often consisting of bundles of capillary rays. Generally the posterior slope is darker green on account of the more crowded rays. In old shells the rays become obscure, and the whole surface turns greenish black. Growth-rests rather distinct, and mostly marked by darker (brown) color.

Hinge-teeth well-developed, but not heavy, rather delicate. Pseudocardinals lamellate, directed forwards, and almost parallel to the hinge. Interdental projection of left valve well-developed, fitting into an interdental groove of the right valve. Lateral teeth rather long, straight, well-developed, but thin. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Nacre white, often cream-color or even pale salmon or flesh-color towards the beak-cavity.

		L.	H.	D.
Size: 1.	Linesville, Cat. No. 61.874	121 mm.	67 mm.	39 mm.
2.	Shenango, Cat. No. 61.4218	91 "	55 "	29 "
3.	do. do.	87 "	53 "	28 "
4.	do. do.	50 "	31 "	12 "

Soft parts (See Ortmann, 1912, p. 281). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 23; Ortmann, 1911, Pl. 89, fig. 10; Surber, 1912, Pl. 3, fig. 44). Surber gives the dimensions as 0.353 × 0.313 mm., while I found them to be: 0.34 × 0.28 mm.

This species normally is *hermaphroditic*, and I never have found a specimen in Pennsylvania having the male structure of the gills. However on rare occasions individuals with male structure seem to turn up. I have recorded (1911*b*, p. 309) such a case from Lake Erie, but this has remained the only one.

Breeding season: Gravid specimens were found on August 6, 1908; August 7, 1908; August 13, 1906; August 18, 1909; August 23, 1916; August 29, 1910; Sept. 2, 1908; Sept. 3, 1908; Sept. 4, 1908; Sept. 7, 1908; Sept. 7, 1913; Sept. 10, 1906; Sept. 14, 1908; Sept. 18, 1916; Sept. 21, 1908; Sept. 27, 1909; Oct. 4, 1910; Oct. 10, 1907; Oct. 15, 1907; Oct. 19, 1908; and then again on May 14, 1908; May 22, 1908; May 23, 1908; June 2, 1908; June 17, 1909. The first record for glochidia is on Sept. 7, while discharging specimens have been observed on May 23, and June 2 and 17.

Thus this species is clearly *bradytictic*, beginning to breed early in August, gravidity lasting till May and June of the following year, when the glochidia are discharged. The interim between two succeeding breeding seasons falls into the second half of June and in July.

Remarks: As to the specific name see the controversy between Frierson (1915, p. 57) and Walker (1915, p. 74).

This is a species easily recognized by the shape and color of the shell, and by the conformation of the hinge. It can only be confused with its nearest relative, *L. subviridis*, but only in the young stage. Young specimens of *L. viridis* indeed somewhat resemble older specimens of *L. subviridis* (Compare figs. 2 and 4, on Plate IX) but they are always more distinctly trapezoidal, with well-developed posterior wing. In other respects the size of full-grown specimens distinguishes the two species at once. In Pennsylvania the geographical distribution is a good diagnostic character, but this is not the case in New York, where the two species overlap.

There is not much variation in the shell. The posterior wing may be more or less developed, and the shell may be more or less elevated at the upper posterior

angle. The degree of compression is also variable; some specimens being more swollen in the region of the posterior ridge than others. Furthermore, some specimens are more elongated than others, but all these are individual variations, and I never have noticed any distinct tendency to form local races.

Specimens from Conneaut Creek (Erie-drainage) do not differ from the normal form of the Ohio-drainage. Specimens from the headwaters of the Genesee River are identical with the type. The only two specimens I collected from Lake Erie were not from the lake proper, but from beach-pools, cut off from the lake by

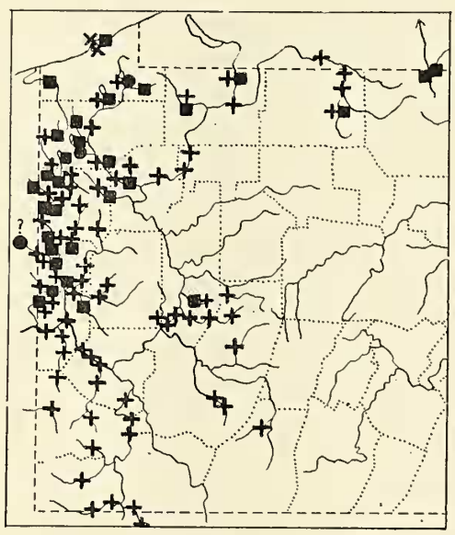


Fig. 12.

■ *Lasmigona viridis.*
● *Lasmigona complanata.*
\+ *Lasmigona costata.*
× *Lasmigona costata eriganensis.*

sand-bars. They are entirely normal, but have a peculiar rusty brown tint in the epidermis, such as is found in other Naiades from Lake Erie, and especially in specimens from the beach-pools. A third individual from the lake, from Cedar Point, Ohio, is also normal in color.

Localities in Pennsylvania represented in the Carnegie Museum:

Little Beaver Creek, Cannelton (Miss Vera White) (H. H. Smith), Darlington and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Brush Creek, Celia, Beaver Co.
Mahoning River, Mahoningtown, Lawrence Co.
Neshannock Creek, Eastbrook, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.
Randolph Run, Hartstown, Crawford Co.

Allegheny-drainage:

Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Crawford Co.; Union City, Erie Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Conneauttee Creek, Edinboro, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

Lake-drainage:

Conneaut Creek, West Springfield, Erie Co.
Lake Erie, beach-pools of Presque Isle, Erie, Erie Co.
Genesee River, Genesee, Potter Co.
Cryder Creek, Genesee, Potter Co.

Other localities represented in the Carnegie Museum:

Lake Erie, Cedar Point, Erie Co., Ohio (C. Brookover).
Tenmile Creek, Lucas Co., Ohio (C. Goodrich) (lake-drainage).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Raisin River, Adrian, Lenawee Co., Michigan (C. Goodrich).
West Branch Nimishillen Creek, Canton, Stark Co., Ohio.
Tuscarawas River, Tuscarawas Co., Ohio (Holland collection).
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.

Distribution and Ecology in Pennsylvania (See fig. 12): The distribution of this species in Pennsylvania is very peculiar, but, as we shall see later, there are several similar cases. It belongs exclusively to the northwestern part of the state, including Little Beaver Creek, the drainage of Beaver River and most of its tributaries, some tributaries of the middle and upper Allegheny (Cowanshannock, Sandy, French, Brokenstraw, Connewango, Potato Creeks), Lake Erie and its drainage, and the upper Genesee River. It has never been found in the Allegheny proper and its drainage from Armstrong Co. down, and is entirely missing in the Ohio proper and in the whole Monongahela system.

Thus it seems as if this species in its distribution does not follow the courses of the rivers, but rather goes across country in the northwestern part of the state, and the relation of its area to that of the Glacial deposits is very close. Only in Little Beaver Creek, below New Galilee, in Brush Creek (tributary to the Con-

noquenessing), Cowanshannock Creek (to middle Allegheny), and Potato Creek (flowing into the uppermost Allegheny), is it outside of the Terminal Moraine, but never far from it. The explanation of this peculiar fact will be attempted elsewhere; here it suffices to direct attention to it, in order that the case may be kept in mind.

As regards its ecology, *L. viridis* is in Pennsylvania distinctly a form of the smaller streams, going up far into the headwaters, into streams which are indeed the smallest in Pennsylvania, which contain mussels. Also Wilson & Clark (1912*a*) have observed that it belongs to the small creeks in the upper Kankakee-drainage in Indiana. Wherever I found this species, it seems to be averse to very strongly flowing waters (in riffles); its usual station is near (below) riffles, where there is a moderate flow of water over coarser or finer gravel, packed firmly by fine sand or mud. It is generally not an abundant species, but locally it has been taken in some numbers. In the beach-pools of Lake Erie I found it in the characteristic sand of the lake-shores, with a scanty vegetation of algæ.

General distribution: Type locality, rare in the Ohio, more common in the Kentucky and small tributaries (Rafinesque).

Simpson (1900) condenses the range as follows: "Ohio and St. Lawrence drainages areas; west to Arkansas, north through Nebraska to Wisconsin; Hudson River." This, however, does not bring out the chief feature of the distribution. This species is distinctly more northern, and its main range is north of the Ohio in Illinois, Indiana, Michigan, Ohio, and Pennsylvania; it crosses over into the lake-drainage (Walker, 1913), and has in the St. Lawrence system a great extension eastwards, crossing over in New York into the Atlantic-drainage (Mohawk and Hudson Rivers). In Canada, it goes as far as the vicinity of Ottawa and Montreal (Marshall, 1895), and extends to Vermont (Call, 1878, and Gray, 1883). It also has been reported from Connecticut.[77]

In this eastern extension of its range it invades in part that of the next species (*L. subviridis*), but it is not known whether it is found in any one locality associated with the latter. Probably it went here (as did *Fusconaia flava*) by way of the Erie Canal, although Call suggests the possibility of distribution by birds.

In the southward direction, in southwestern Pennsylvania, as indicated above, and generally to the South of the Ohio River, it is missing or rare. I have never found it in the Ohio proper from Pittsburg down to Cincinnati, although it is mentioned in the Cincinnati list (Harper, 1896). I have found a single individual

[77] New Haven Canal, according to Linsley (1845), but not mentioned by Perkins (1869). Adams (1842) has distinguished this eastern form as var. *plebeia* (See Simpson, 1914, p. 483, and Johnson, 1915, p. 25).

in North Fork Hughes River, a tributary of the Little Kanawha, and, for the present I regard this as a stray specimen. Rafinesque gives it from Kentucky, also Baker (1898*a*, p. 60), but it is unknown from the Cumberland and Tennessee. The distribution seems to be also very restricted in a southwesterly and westerly direction. The records from Arkansas and Iowa are very vague, and certainly need verification (for Iowa, see Geiser, 1910). It is absent from Call's Arkansas list (1895), and from Scammon's Kansas list (1906). It is abundant in northern Illinois, and passes into parts of Wisconsin and Minnesota, and also into eastern Nebraska. But the exact boundaries in this region require further investigation.

Lasmigona (Platynaias) subviridis (Conrad) (1835).

Symphynota viridis Simpson, 1914, p. 484; *Lasmigona subviridis* (Conard) Frierson, 1915, p. 58.

Plate IX, figs. 3, 4.

Records from Pennsylvania:

Conrad, 1836 (Schuylkill River, Philadelphia; Lancaster; Juniata River).
Lea, 1838 (Juniata River, Hollidaysburg, Blair Co.).
Haldeman, 1844 (Lancaster Co.).
Conrad, 1856 (Schuylkill River, Phoenixville, Chester Co.; Delaware River, Morrisville, Bucks Co.: "opposite Trenton").
Bruckhart, 1869 (Lancaster Co.).
Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Marshall, 1895 (Juniata River and Philadelphia).
Ortmann, 1909*b*, p. 206.

Characters of the shell: Shell very much like that of *L. viridis*, but invariably much smaller, thinner, and more delicate, with the hinge-teeth thin and weak. The interdental projection of the left valve is quite rudimentary, and generally, no indication of it is present. The outline of the shell is not so distinctly trapezoidal, but rather subovate, narrower in front, higher behind, and the upper margin forms only a blunt angle with the posterior margin. The two valves are not so distinctly compressed, as in *L. viridis*, and the swelling in the region of the posterior ridge is generally more pronounced, so that the whole shell appears relatively more inflated. Beak-sculpture similar to that of *L. viridis*, but the bars are stronger and less in number (four); they do not extend so far upon the disk, are more equal, with the posterior loop not so sharply angled (See Marshall, 1890, p. 176, fig. 2). Epidermis yellowish brown to olive greenish, with more or less distinct green rays, which are most distinct and crowded upon the posterior slope, so that the latter generally appears darker green. Nacre white and iridescent, but often with lurid or dirty salmon tints.

			L.	H.	D.
Size: 1.	Greencastle, Cat. No. 61.4222 (largest at hand)		63 mm.	38 mm.	26 mm.
2.	Yardley, Cat. No. 61.3689		55 "	32 "	20 "
3.	do.	do.	51 "	31 "	19 "
4.	do.	do.	41 "	25 "	15 "

Soft parts (See Ortmann, 1912, p. 282). *Glochidia* (See Lea, Obs. XII, 1874, Pl. 21, fig. 4). Measurements: 0.36 × 0.30 mm.

This species is also normally *hermaphroditic*, and specimens with male structure have never been found. Since the first publication of this fact I have examined several hundreds of additional specimens, but all had the female characters in the gills.

Breeding season: Gravid females have been collected at the following dates: Aug. 13, 1910; Aug. 20, 1909; Aug. 24, 1908; Sept. 5, 1909; Sept. 6, 1909; Sept. 12, 1912; Sept. 14, 1912; Sept. 16, 1912; then again: April 24, 1909; May 6, 1912; June 8, 1912. Thus the season begins about the middle of August. The first date for the presence of glochidia is September 5. The glochidia are carried

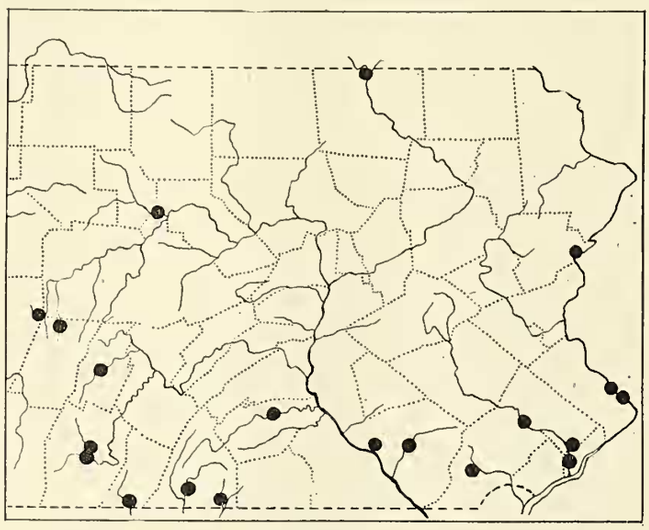


Fig. 13.

● *Lasmigona subviridis.*

over the winter, and discharge was observed on the last date, June 8. The species is *bradytictic*.

Remarks: Although this species morphologically is closely allied to *L. viridis*, and is undoubtedly its eastern representative, and although the differences are only in the degree of development of certain characters, it is not difficult to distinguish it at the first glance on account of the shape and size of shell. The range

of variation is not very great, and chiefly lies in the color of the epidermis. One peculiar local phase, however, deserves special mention. In Conococheague Creek at Greencastle, Franklin Co., this species is represented by rather large specimens, which have an unusually heavy shell, with the nacre more frequently of a clear salmon color, and the beaks in a beautiful state of preservation, even in large individuals. This creek, at that locality, is so heavily charged with lime (fed by big limestone springs), that a deposit of calcareous ooze is formed at the bottom, and there is no doubt, that the peculiar local development is due to these local conditions. Something similar, but not so strongly pronounced, has been observed in Conedoguinet Creek at Carlisle; and in Virginia, in Reed Creek at Wytheville, under the same conditions, a form has been observed, which corresponds entirely to this form from Greencastle.

Localities in Pennsylvania represented in the Carnegie Museum:

Delaware-drainage:

Delaware River, Yardley, Bucks Co.; Shawnee, Monroe Co.
Schuylkill Canal, Manayunk, Philadelphia Co.

Susquehanna-drainage:

Conedoguinet Creek, Carlisle, Cumberland Co.
Dunning Creek (J. F. L. Raschen) and Raystown Branch of Juniata River (A. Koenig), Bedford, Bedford Co.
Chest Creek, Patton, Cambria Co.
Cush Cushion Creek, Green Township, Indiana Co. (D. A. Atkinson).
Chemung River, South Waverly, Bradford Co.

Potomac-drainage: [78]

Conococheague Creek, Greencastle, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

"Valley Creek" [79] southwest of Coatesville, Chester Co. (C. H. Conner).
Pennsylvania Canal, "Chicques,"[80] Pennsylvania (S. S. Haldeman).
Sinnemahoning Creek, Round Island, Clinton Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
South Branch Potomac River, Southbranch and Romney, Hampshire Co., West Virginia.

[78] I found this species abundant in Little Antietam Creek, Waynesboro, Franklin Co., but the specimens collected (about a dozen), on Aug. 10, 1910, were lost during the trip in an unaccountable way.

[79] There is no creek of this name on the map, but "Sucker Run" is in the "valley" southwest of Coatesville, tributary to West Branch Brandywine Creek.

[80] No doubt "Chickies," near Columbia, Lancaster Co.

Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.
Rappahannock River, Remington, Fauquier Co., Virginia.
Rapidan River, Rapidan, Culpeper Co., Virginia.
North River, Buena Vista, Rockbridge Co., Virginia.

Kanawha-drainage:

Pool of Kanawha River, Glen Ferris, Fayette Co., West Virginia.
Greenbrier River, Ronceverte, Greenbrier Co., West Virginia.
New River, Hinton, Summers Co., West Virginia; Pearisburg, Giles Co., Virginia.
Reed Creek, Wytheville, Wythe Co., Virginia.

Distribution and Ecology in Pennsylvania (See fig. 13): According to the records at hand, this species is very erratic in its distribution. It is found in all three drainages on the Atlantic side, but it is evident that it avoids the large rivers and prefers smaller streams. Its absence in the lists of Gabb (1861)[81] and Schick (1895) is significant, although, as I have discovered, it is abundant in the Schuylkill Canal at Manayunk. The specimens found by myself in larger rivers generally were few, and often in small branches of the river.

But even in small streams, it is not everywhere present. But generally, when found, it turned up abundantly. Like the preceding species (*L. viridis*), it is averse to very strong current, and prefers more quiet parts, pools or eddies with gravelly and sandy bottoms, and it also goes into canals, where it seems to flourish. In the Susquehanna-drainage it goes far up into the headwaters, advancing westward to Bedford, Cambria, and Indiana Cos.

Outside of Pennsylvania, it is found under similar conditions, and is also more abundant in smaller streams. In the Kanawha-drainage it descends to the big pool above the Kanawha falls, where it lives in an environment resembling a lake.

General distribution: Type locality, Frankstown Branch Juniata River, Hollidaysburg, Blair Co., Pennsylvania (Conrad).

Simpson (1900) gives: "streams draining into the Atlantic from New York south to North Carolina," and "Monroe Co., Michigan?". Of course, this latter locality, doubted already by Walker (1898), is certainly incorrect. We possess the largest number of locality records, outside of Pennsylvania, from the state of New York (Marshall, 1895), where it is found in the drainages of the Susquehanna and Hudson Rivers, and it goes westwards through the Mohawk into the Erie Canal, reaching the Genesee River (See Baker, 1898*b*). As has been said above, in this region it overlaps *L. viridis*, but particulars as to the mutual relations of these two species are absent.

[81] Gabb mentions it as a species, which might be found near Philadelphia. Conrad (1836) reports a single individual from the Schuylkill at Philadelphia.

South of Pennsylvania records become scarce, and aside from those given by myself we have only the following: Sideling Creek, Allegany Co., Maryland (Pilsbry, 1894); Richmond, Henrico Co., Virginia (Lea's *U. hyalinus*); and Neuse River, Raleigh, Wake Co., North Carolina (Lea's *U. pertenuis*).

My discovery of the presence of this species in the upper Kanawha-drainage in Virginia and West Virginia is quite astonishing and has been discussed elsewhere (Ortmann, 1913*a*, p. 371, fig.). It should be added, that further investigations have traced this species down to the Big Pool of the Kanawha (at Glen Ferris, in Fayette Co., West Virginia).

Subgenus Lasmigona Rafinesque (1831).

Simpson, 1914, p. 488; Ortmann, 1914, p. 43.

Type *Alasmidonta costata* Rafinesque.

One species and one variety belong here.

Key to the Forms of Lasmigona.

a_1. Shell compressed, not subcylindrical. . . . . *L.* (*L.*) *costata.*

a_2. Shell more swollen, and thus more nearly subcylindrical. . . . . *L.* (*L.*) *costata eriganensis.*

Lasmigona (Lasmigona) costata (Rafinesque) (1820).

Symphynota costata (Rafinesque) Simpson, 1914, p. 488.

Plate IX, fig. 5.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).

Stupakoff, 1894 (Allegheny Co.).

Marshall, 1895 (Allegheny River, Warren Co.).

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).

Ortmann, 1909*b*, p. 196.

Characters of the shell: Shell rather large, moderately solid. Outline subrhomboidal or subtrapezoidal, more or less elongated. Anterior end rounded, posterior obliquely truncate. Lower margin gently convex, or almost straight. Upper margin straight or slightly curved, somewhat ascending posteriorly, and forming a rounded angle with the posterior margin. Beaks not prominent, placed in front of the middle of the shell. Beak-sculpture consisting of about four or five bars, which are rather heavy and swollen, the first simply curved, the others with a tendency to fall into two loops, but this is distinct only in the second and third bar, where the posterior loop is angled, and the sinus is present, but not

sharp. The later bars are only developed in the middle, and have only a slight sinuation (see Marshall's figure, 1890, fig. 10). Shell rather flat, and more or less compressed, with an indistinct, blunt posterior ridge. Greatest diameter in the middle of the disk, or somewhat posterior to it, immediately in front of the posterior ridge, and in this case the sides of the disk are flattened. Behind the posterior ridge, the posterior slope is corrugated by heavy, blunt ridges or ribs, running toward the posterior margin. In front of the posterior ridge, the disk is smooth, without sculpture (sometimes there are short vertical grooves, such as are found incidentally also in other Naiades).

Epidermis yellowish or brownish olive, greenish, brownish or blackish, with more or less distinct, narrower or broader, dark green rays, which disappear in old shells, which are more or less uniformly brownish or greenish black. Growth-rests irregular, more or less distinct, often marked by darker bands.

Hinge partly obliterated. The pseudocardinals are moderately developed (sometimes heavy in old shells), of the characteristic Anodontine type (more or less lamellar and directed obliquely forwards), with the interdental projection very well developed. Lateral teeth practically absent, or indicated only by mere rudiments. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre white, often cream-color or pale salmon, chiefly so toward the beak-cavities.

No material sexual differences are seen in the shell. It has been asserted by Scammon (1906) that the shell of the female is shorter and more inflated, while Call (1900, p. 525) says that the females are a little more obese than the males. According to my experience large specimens, which are rather swollen just in front of the posterior ridge, are generally females (See Nos. 1 and 3 in table of measurements) but there are females, which do not show this character (See No. 2), and in medium-sized and small shells it is not at all developed (Compare Nos. 4–9). As a rule, it is not easy to positively identify the sex by the shell alone, and in younger shells this is impossible. That the females are shorter than the males is not at all correct (See table of measurements).

	L.	H.	D.	
Size: 1. Enon Valley, Cat. No. 61.3134	149 mm.	86 mm.	50 mm.	(swollen ♀, largest at hand)
2. do. do.	137 "	76 "	37 "	(flat ♀)
3. Waynesburg, Cat. No. 61.4709	134 "	77 "	45 "	(swollen ♀)
4. Harbison, Cat. No. 61.4710	126 "	71 "	35 "	(swollen ♂)
5. Mount Morris, Cat. No. 61.4711	126 "	67 "	36 "	(♀)
6. Waynesburg, Cat. No. 61.4709	122 "	72 "	35 "	(♂)
7. Harbor Bridge, Cat. No. 61.3709	122 "	67 "	32 "	(flat ♀, gravid!)
8. Harbison, Cat. No. 61.4710	75 "	41 "	19 "	(♂)
9. Wurtemberg, Cat. No. 61.4712	73 "	41 "	18 "	(♀)

Soft parts (See Ortmann, 1912, p. 283). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 26; Lefevre & Curtis, 1910, p. 97, fig. B, and 1912, p. 146, fig. B; Surber, 1912, Pl. 1, fig. 7). Surber gives the following dimensions: 0.385 × 0.390; Lefevre & Curtis: 0.35 × 0.39; while I (1912) give: 0.34 × 0.37 mm.

Breeding season: I have the following records for gravid females: August 3, 1909; Aug. 8, 1914; Aug. 9, 1907; Aug. 23, 1916; Aug. 29, 1910; Aug. 31, 1906; Sept. 2, 1907; Sept. 2, 1908; Sept. 4, 1908; Sept. 5, 1908; Sept. 5, 1913; Sept. 7, 1908; Sept. 7, 1913; Sept. 10, 1906; Sept. 11, 1913; Sept. 12, 1913; Sept. 13, 1910; Sept. 13, 1915; Sept. 15, 1913; Sept. 17, 1912; Sept. 17, 1917; Sept. 18, 1917; Sept. 21, 1907; Sept. 21, 1908; Sept. 27, 1909; Sept. 28, 1911; Oct. 4, 1910; Oct. 14, 1907; Oct. 15, 1907; Oct. 19, 1908; Oct. 23, 1907. Then again in spring: April 22, 1908; April 24, 1908; May 11, 1907; May 11, 1911; May 13, 1910; May 17, 1910; May 26, 1908.

Thus this species is *bradytictic*. The breeding season begins early in August, and by the end of this month (earliest date Aug. 31), and in September, glochidia begin to be present. They are carried over the winter, and are found in the marsupium in April and May, and are discharged during May (observed on May 11 and 13). In June and July, there is an "interim," and although many specimens were collected, there never was in these months a gravid female among them.

Remarks: This species is easily recognized by the general shape, sculpture of the posterior slope, and conformation of the hinge. From *L. viridis*, which it resembles somewhat in shape, it differs also in beak-sculpture. Variations are chiefly due to differences in the relation of length to height, and the development of the sculpture of the posterior slope, which may be coarser or finer, and may be more or less distinct; but traces of this sculpture are always present. I have not been able to discover any marked tendency in the direction of the development of local races, unless it be in size, the forms of certain creeks always remaining comparatively small. This is especially true of some little streams in the mountains (upper Loyalhanna River in Westmoreland Co., Quemahoning Creek in Somerset Co., Little Mahoning Creek in Indiana Co.). Other small creeks, chiefly in the northwestern part of the state, favor the development of almost gigantic forms, for instance, Little Beaver Creek, the upper Shenango River, and others.[82]

[82] I found outside of our state in the upper Tygart River at Elkins, Randolph Co., West Virginia, a rather interesting local form, with a very pronounced tendency toward the obliteration of the sculpture of the posterior slope, which in these specimens in most cases is perfectly smooth, although individuals occur, which show rudiments of the ribs.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River and its smaller tributaries:

Ohio River, Industry, Beaver Co.; Dead Man's Island, Allegheny Co. (R. Foerster); Neville Island, Allegheny Co.

Buffalo Creek, Aeheson, Washington Co.

Little Beaver Creek, Cannelton (Miss Vera White, H. H. Smith), Darlington and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, New Sheffield, Beaver Co.; Bavington, Washington Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson).[83]

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith); Harmony, Butler Co.

Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.

Little Connoquenessing Creek, Harmony, Butler Co.

Mahoning River, Mahoningtown, Coverts, Edinburg and Hillsville, Lawrence Co.

Neshannock Creek, Volant, Lawrence Co.; Leesburg, Mercer Co.

Otter Creek, Mercer, Mercer Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Little Shenango River, Greenville, Mercer Co.

Allegheny-drainage:

Allegheny River, Godfrey, Kelly, Mosgrove, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Eldred, McKean Co.; Larabee, McKean Co. (Dennis Dally).

Buffalo Creek, Harbison, Butler Co.

Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.

Two Lick Creek, Homer, Indiana Co.

Quemahoning Creek, Stantons Mill, Somerset Co.

Crooked Creek, Rosston and South Bend, Armstrong Co.; Creekside, Indiana Co.

Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).

Little Mahoning Creek, Goodville, Indiana Co.

Sandy Creek, Sandy Lake, Mercer Co.

French Creek, Utica, Venango Co.; Cochranton and Meadville, Crawford Co.

Sugar Creek, Cooperstown, Venango Co. (E. P. Spencer).

Conneauttee Creek, Edinboro, Erie Co.

Leboeuf Creek, Waterford, Erie Co.

Brokenstraw Creek, Garland, Warren Co.

Connewango Creek, Russell, Warren Co.

Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

Monongahela-drainage:

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson); Charleroi, Washington Co. (G. A. Ehrmann); Westmoreland Co. (G. A. Ehrmann).

[83] Dead shell seen in Little Chartiers Creek, Morganza, Washington Co.

Ten Mile Creek, Amity, Washington Co.
South Fork Ten Mile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

Ohio River, Beaver, Beaver Co., and Coraopolis, Allegheny Co. (S. N. Rhoads).

Other localities represented in the Carnegie Museum:

Atlantic- and Lake-drainage:

Mohawk River, New York (Smith collection).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Waterville, Lucas Co., and Defiance, Defiance Co., Ohio (C. Goodrich).
St. Marys River, Rockford, Monroe Co., Ohio (C. Goodrich).
Raisin River, Grape P. O., Monroe Co., Michigan (C. Goodrich).
Kaministiquia River, Stanley, western Ontario, Canada (O. E. Jennings).[84]

Ohio-drainage:

Ohio River, Portsmouth, Scioto Co., Ohio.
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Rock River, Illinois (Smith collection).
Cheat River, Jaco and Mount Chateau, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Tygart River, Elkins, Randolph Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Sutton and Gassaway, Braxton Co.; Shelton, Clay Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Fayetteville, Lincoln Co., and Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Flint River and Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Rock River, Trenton and Princeton, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Tennessee River, Knox Co., Tennessee (Smith collection).
Boyd Creek, Boyd Creek, Sevier Co., Tennessee.
Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill and Church Hill, Hawkins Co., Tennessee.

[84] About 15 miles west of Fort Williams on the Kaministiquia River, which flows to Lake Superior, but it might have a connection with the Hudson Bay-drainage. Special attention should be called to this new locality!

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.

Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.

Clinch River, Edgemoor and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

Distribution and Ecology in Pennsylvania (See fig. 12): This species is widely distributed in the headwaters of the Ohio in western Pennsylvania, and is found in large rivers as well as in very small creeks, although it is distinctly more abundant in the latter. There is hardly any small stream from which it is entirely absent, but in the large rivers, although present, it is decidedly rare.

The wide and general distribution of this species indicates that it is not very particular as to station. It is found under a great variety of conditions, in riffles, with a strong and variable current, in steady, stronger or weaker currents, and even in rather quiet water and deep pools. It is found on every variety of bottom, but prefers coarser or finer gravel, and more rarely is seen in sand and mud. It is one of the few species, which advances far eastwards in the headwaters of the Conemaugh and Allegheny drainages, but although it closely approaches the divide, it has never been found in Pennsylvania to the east of it in the Atlantic-drainage.

It has not been found in the only tributary of Lake Erie in our state, which has shells (Conneaut Creek).

General distribution: Type locality, Kentucky River (Rafinesque).

This species has an enormous range. It is found practically all over the Mississippi and Ohio-drainages, from western Pennsylvania throughout Ohio, Indiana, Illinois, West Virginia, Kentucky, and Tennessee to northern Alabama. In the upper Tennessee-drainage it goes by the Powell, Clinch, and Holston Rivers into Virginia. In a southwesterly direction it extends to eastern Kansas, through Arkansas to Oklahoma and northern Louisiana.

Simpson cites it from Columbus, Lowndes Co., Mississippi, in the Tombigbee-drainage, but this is the only place from which it has been recorded in the Alabama system.

Westward it does not seem to go beyond Iowa (abundant in the Wapsipinicon, Volga, and Turkey Rivers, in northeastern Iowa, according to Geiser, 1910), but in a northerly direction it has crossed over into the Hudson Bay-drainage in Manitoba, and possibly our locality in a northern tributary of Lake Superior (Kaministiquia River), is connected with this region.

In the drainage of the Great Lakes, from Wisconsin through Michigan to New York and eastern Canada it is widely distributed. However this latter part of its range should be investigated more closely. As we shall presently see, in Lake Erie a peculiar local variety has been developed. Nevertheless in the lake-drainage in western and central New York the normal type is present. Here it advances along the Erie Canal to the Mohawk and even to the Hudson River. It follows the lower St. Lawrence down to the neighborhood of Ottawa and Montreal (and also occurs in the Lake Champlain region), but it is not known whether the form peculiar to Lake Erie or the normal type prevails here.

It should be further noted that the rule that this species is rare in large rivers holds good also in the Ohio below Pittsburgh. Between the Pennsylvania state-line and Cincinnati, I found only a single individual (in a clam-digger's pile at Portsmouth, Scioto Co., Ohio). This is in strong contrast to the abundance of this species in some of the smaller creeks in West Virginia and Kentucky.

Lasmigona (Lasmigona) costata eriganensis Grier (1918).

A form, not distinguished hitherto, except by Sterki (1907*a*, p. 393) who called attention to its peculiarities, and by Grier (1918, p. 10) who elevated it to the rank of a variety.

Plate IX, fig. 6.

Characters of the variety: Shell smaller, slightly more elongate, more swollen, and thus approaching in a degree the subcylindrical shape. Ridges of posterior slope generally narrower. Color lighter, more yellowish-brown, sometimes rusty brown, with the rays indistinct, and the growth-rests more distinct and more regular.

				L.	H.	D.	
Size: 1.	Presque Isle Bay,	Cat. No. 61.4223		90 mm.	44 mm.	31 mm.	Type Set
2.	do.	do.		88 "	45 "	26 "	" "
3.	do.	do.		85 "	46 "	29 "	" "
4.	do.	do.		76 "	39 "	28 "	" "
5.	do.	do.		73 "	38 "	25 "	" "

Compared with the measurements of typical *costata* (p. 126), the differences in shape become evident, especially the greater diameter.

Soft parts: Living specimens have been found only on two occasions: May 22, 1909; and July 8, 1910. Although there were females among them, none were gravid. The soft parts of none were preserved, but as far as I am able to recollect, they were not different from the normal form.

Remarks: Although I have only fifteen specimens from Pennsylvania, and five from Michigan (to which might be added about half a dozen individuals used

in exchange) I feel quite sure, that Grier is right in thinking that this shell represents a very peculiar phase of *L. costata*. The whole outer aspect of this shell is quite unlike that of the normal form, but, of course, the sculpture of the posterior slope and the hinge do not leave any doubt as to its systematic relationship. As the above measurements show, there is some variation in shape, and furthermore the color of the epidermis may be lighter or darker, sometimes inclining more to brown, sometimes to rusty. Greenish tints are rarely seen.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Distribution and Ecology (See fig. 12). *Type locality:* Lake Erie; Presque Isle Bay, Erie, Erie Co., Pennsylvania. *Type set:* Carnegie Museum Cat. No. 61.4223 (not 61.4720, as Grier states!).

I know this form only from the Lake Erie shores in Pennsylvania and Michigan, but according to Sterki it also occurs on the Ohio shores, and very likely will be found elsewhere in Lake Erie. Walker's (1913, p. 22) *S. costata* from Lake Erie is undoubtedly this form. The specimens collected by myself are all from the north shore of the bay "Big Bend," where I found them alive in one to three feet of water, on sand and fine gravel, without vegetation, and at places, which are exposed at times to a considerable surf. This form is not abundant there. Some specimens were found among a scanty growth of rushes (*Juncus americanus*).

Note: Since it is possible that *L. costata* of western New York may have come by way of Lake Erie, it is interesting to observe that the typical *L. costata* is found in this region, as indicated by De Kay's figure (1843, Pl. 14, fig. 226) from Oswego River (Lake Ontario-drainage). This possibly is a case parallel to others mentioned above, where the lake-form, when migrating into the tributaries, assumes again the shape of the normal creek-form. The matter, however, is not perfectly clear, for there is the possibility that western and central New York was reached by way of the upper Allegheny.

Subgenus Pterosyna Rafinesque (1831).[85]

Pterosygna Simpson, 1914, p. 490; Ortmann, 1914, p. 43.

Type *Unio complanatus* Barnes.

Only one species is known to belong to this subgenus.

[85] *Pterosyna*, and not *Pterosygna*, as Simpson writes.

LASMIGONA (PTEROSYNA) COMPLANATA (Barnes) (1823).

Symphynota complanata (BARNES) SIMPSON, 1914, p. 490.

Plate IX, fig. 7.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 196.

Characters of the shell: Shell large; rather thin when young, moderately solid when old. Outline broadly ovate, subrhomboidal, not elongate, only a little longer than high. Anterior end rounded, posterior obliquely truncate. Lower margin convex, less so posteriorly. Upper margin nearly straight, strongly ascending posteriorly, forming a distinct angle with the posterior margin, and projecting so as to form a very distinct wing, the upper margin of which is symphynote. The wing is best developed in young specimens. Beaks not prominent, placed in front of the middle of the shell. Beak-sculpture consisting of four to five rather distinct and sharp bars, the first one or two simply curved, the others strongly double-looped, with the anterior loop round and wide, the posterior narrower and angled, and with a sharp, re-entering angle between them. Shell flat and greatly compressed, with an indistinct, blunt and broad posterior ridge. The posterior slope is alate and strongly compressed, and in many cases is ornamented with irregular ridges running toward the posterior margin, which, however, may be entirely absent. Disk in front of posterior ridge smooth, without sculpture.

Epidermis yellowish to greenish brown; when young with indistinct traces of green rays, which become entirely obsolete in older shells, of which the epidermis is lighter or darker brown, often blackish. Sometimes there is some dark green in the epidermis. Growth-rests more or less distinct, often marked by darker color.

Hinge-teeth partly obliterated. Pseudocardinals present and rather heavy, and quite variable in shape. Interdental projection variable, sometimes rather distinct; in other cases weak, and often entirely absent. Lateral teeth practically absent, indicated only by vestigial blunt ridges. The conformation of the hinge in this species is extremely and remarkably variable. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre white, sometimes lightly tinted with cream-color toward the beak-cavity.

No differences in the shape of the shell in the two sexes. Baker (1898*a*, p. 60) and Scammon (1906, p. 332) say that the male is more compressed than the female. This is not at all correct, as is easily seen by comparing nos. 2, 3, and 4, and nos. 5 and 6 in our table of measurements.

		L.	H.	D.
Size: 1.	Conneaut Outlet, Cat. No. 61.3315 (♂)	124 mm.	93 mm.	40 mm.
2.	Waterford, Cat. No. 61.4238 (♂)	118 "	86 "	40 "
3.	do. " " do. (♀)	118 "	84 "	39 "
4.	Conneaut Outlet, Cat. No. 61.3315 (♀)	117 "	88 "	35 "
5.	do. " " do. (♀)	93 "	71 "	23 "
6.	Waterford, Cat. No. 61.4237 (♂)	90 "	65 "	25 "
7.	do. Cat. No. 61.4238 (♂)	78 "	60 "	21 "

Outside of Pennsylvania this species grows much larger.

Soft parts: Figured by Lefevre & Curtis, 1910, Pl. 1, fig. 6, and 1912, Pl. 6, fig. 3; described by Ortmann, 1912, p. 282. *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 29; Lefevre & Curtis, 1910, p. 97, fig. A, and 1912, p. 146, fig. A; Ortmann, 1911*b*, Pl. 89, fig. 11; Surber, 1912, Pl. 1, fig. 6. Lefevre & Curtis give the dimensions: 0.28 × 0.30 mm.; Surber: 0.310 × 0.320; while I gave: 0.34 × 0.34 mm.

Breeding season: I found gravid females on September 14, 1909; September 22, 1910; and May 14, 1908. Glochidia were observed on the first and last dates. Although these records are very meager, yet they distinctly indicate that we have to deal with a bradytictic form, which carries the glochidia over winter. According to Surber (1912, p. 7), this species is gravid in October, November, and May.

Remarks: An extremely characteristic species, which in its external shape greatly resembles *Proptera alata* (Say), but may be distinguished at once by the color of the nacre (white, not purple), by the hinge, and some minor characters. The similarity of the outer shape of these two species, belonging to different subfamilies, is very remarkable, and offers a very good example of parallel, but independent, development of the same external characters ("convergency").

Aside from slight differences in outline and the variability of the hinge, this species varies chiefly in the development of the sculpture of the posterior slope. In Pennsylvania both conditions, specimens with well-developed sculpture, and with practically smooth shells, are found side by side, accompanied by all transitional stages. In size the Pennsylvanian shells remain far below the dimensions recorded for specimens from farther west (Scammon gives: L. 188; H. 110; D. 52 mm.).

Localities in Pennsylvania represented in the Carnegie Museum:

Conneaut Outlet, Conneautlake, Crawford Co.

Leboeuf Creek, Waterford, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

St. Josephs River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

Ohio-drainage:

Ohio River, Wheeling, Ohio Co., West Virginia (W. F. Graham); Portland, Meigs Co., Ohio.[86]
Wolfe Creek, Wolfe Creek P. O., Washington Co., Ohio (W. F. Graham).
West Fork White River, Riverside, Green Co., Indiana (J. D. Haseman).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).
Middle Island Creek, Union Mills, Pleasants Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.

West of Mississippi:

Roehé-Perehé Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Solomon River, Salina, Saline Co., Kansas (R. L. Moodie).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Chikaskia River, Tonkawa, Kay Co., Oklahoma (F. B. Isely).

Alabama-drainage:

Big Prairie Creek, Hale Co., Alabama (Dr. Showalter, Hartman collection).
Cahaba River, Gurnee, Shelby Co., Alabama (H. H. Smith).

Distribution and Ecology (See fig. 12): *Type-locality*, Fox River, Wisconsin (Barnes).

The distribution of this species in Pennsylvania is very remarkable. It is found only in two places; in both in the outlet of a glacial lake. At Conneaut Outlet I found this species in rather strongly flowing water, with a soft bottom of muddy sand; in Leboeuf Creek in a soft shell-marl. At both places the size of the stream is about the same, rather small, with the supply of water uniform, regulated by the lake above.

While at both localities the species is quite frequent, no trace of it has ever been found in any other stream in this state. Down the Ohio, it turns up for the first time at Wheeling, and further down at St. Marys, Parkersburg, and Portland. But at St. Marys it is not in the Ohio proper, but in the slackwater of Middle Island Creek, which goes up about five miles (to Union Mills). In the Kanawha-drainage it goes up to Pocatalico River, in the lower part of which it is not rare, being chiefly found in quiet and muddy pools.

L. complanata has been reported to prefer deep and quiet water with muddy bottoms (Baker, 1898*a*, Call, 1900, Scammon, 1906) although Scammon mentions that it is occasionally found in riffles and in gravel. I have found it under such conditions in the smaller branch of the Ohio at Portland, but only a single individual. The lack in Pennsylvania of the environment it prefers accounts for its absence in the upper Ohio-drainage in general. So much more astonishing is its presence in the outlets of two glacial lakes, and I am not prepared to say, which

[86] I have also seen dead shells at Parkersburg, Wood Co., West Virginia, in the small branch of the Ohio at Neal Island.

are the environmental features, which have favored its establishment there. Furthermore the question remains to be answered how it succeeded in reaching these isolated stations.

With regard to this phenomenon, attention may be called to the fact that this species, although distributed over the whole state of Ohio (Sterki, 1907*a*), is especially found in its northeastern part, not far from the Pennsylvanian localities. Dean reports it from Mahoning River;[87] Silver Creek, Portage Co.; and from Cuyahoga River (lake-drainage). It seems that there might be here a connection with the Pennsylvanian localities, and then this species very likely would belong in the same category as *Lasmigona viridis* (see above).

This species has a very wide distribution, and is found according to Simpson (1900) in the "upper Mississippi-drainage as far south as Arkansas in the west; Ohio River-system; upper St. Lawrence and its tributaries, north into Mackenzie River." A number of localities are known in the Lake Winnipeg and Nelson drainages; in Lake of the Woods belonging to the upper Lakes drainage. It occurs also in Michigan (Walker, 1898) in the lake-drainage, and in Rouge River at Detroit belonging to the Lake Erie-drainage. It is found in the Erie-drainage in Indiana and Ohio (Goodrich, 1914, Dean), but it has never been reported from Lake Erie proper (Walker, 1913, p. 22). A record from Buffalo cannot be credited on account of the general inaccuracy of this list, and Call's "western New York" remains unconfirmed (Marshall, 1895). In addition, it goes southward into the Alabama-drainage, according to Call (1885) and Lewis (1877) (See also specimens in Carnegie Museum). Strangely enough localities from South of the Ohio in Kentucky and Tennessee are not known, except the record of Wilson & Clark (1914) from the Cumberland in Tennessee. Apparently, the Alabama localities are connected with the rest of the range not in a northerly, but in a westerly direction. The species is found in northern Louisiana (Marshall, 1895; Vaughan, 1893). It extends westward to Iowa, Kansas, Arkansas, and Oklahoma.

Note: Simpsoniconcha ambigua (Say) (1825).
Hemilastena ambigua (Say) Simpson, 1914, p. 325.[88]

This species has never been found in Pennsylvania. According to Simpson it is distributed in the "Ohio River system; north to Michigan; west to Iowa; south to Arkansas; east to Tennessee." According to Dean (1890), it is rare in the Mahoning River, Ohio, but I have hunted for it in vain in the Pennsylvanian part of this river.

[87] No trace of it in the Pennsylvanian part of this river.

[88] As to the generic names *Simpsonaias* and *Simpsoniconcha*, see Frierson, 1914*a*, p. 7, and 1914*b*, p. 40.

On May 23, 1912, I found a single specimen of this species in the headwaters of the Monongahela in West Fork River, Lightburn, Lewis Co., West Virginia. I found it buried deeply in sand and gravel held together by the rhizomes and roots of *Dianthera*.

Being thus present in two rivers, which run into our state, it might have once existed here, or else it accidentally may have escaped detection.

The systematic position of this genus is as yet quite uncertain. The account of the anatomical structure given by Simpson is quite unsatisfactory, in fact partly unintelligible. Besides the nomenclature of the genus requires final adjustment.

Genus Anodonta Lamarck (1799).

Ortmann, 1912, p. 286; Simpson, 1914, p. 358.

Type *Mytilus cygneus* Linnæus.

A large number of species of this genus are known, many of which may be only special phases of others. In Pennsylvania, four species and one or two varieties may be distinguished, but I am not sure whether all of them are "good species."

Key to the Species and Varieties of Anodonta in Pennsylvania.

a_1. Umbonal region convex, or more or less inflated and elevated above the hinge-line. Beak-sculpture consisting of several rather strong, double-looped bars, which generally have a sharp re-entering or angular sinus. Gonochoristic.

b_1. Beak-sculpture rather heavy, forming distinct nodules on the posterior loop.

c_1. Shell rather compressed, not swollen.

d_1. Shell not very thin, ovate, somewhat elongate. . . . . *A. grandis.*

d_2. Shell rather thin, large, higher and shorter. . . . . *A. grandis gigantea.*[89]

c_2. Shell more swollen and inflated, chiefly in the umbonal region. . . . . *A. grandis footiana.*

b_2. Beak-sculpture less heavy, generally not nodulous, and bars of uniform thickness.

c_1. Shell rather thin or moderately thick, not thickened along the lower anterior margin. *A. cataracta.*

c_2. Shell somewhat thicker, and especially so along the lower anterior margin. . . . . *A. implicata.*

a_2. Umbonal region remarkably depressed and flattened, and not elevated above the hinge-line. Beak-sculpture consisting of several delicate, irregular bars, with a slight tendency to fall into two loops, the sinus being a mere notch. Hermaphroditic. . . . . *A. ohiensis.*

[89] I shall not treat this as a "variety." It has been introduced here only to bring out its characters.

Anodonta grandis Say (1829).

Anodonta grandis Say; Simpson, 1914, p. 418.

Plate X, figs. 1, 2.

Records from Pennsylvania: [90]

Ortmann, 1909*b*, p. 195. It is very remarkable that this common species has never before been reported from western Pennsylvania.

Characters of the shell: Shell large, sometimes very large, but generally rather light and thin, often very thin. Outline subovate or subelliptical, more or less elongate, rounded anteriorly, more or less narrowed behind, often somewhat pointed. Lower margin more or less convex, upper margin straight, often forming an angle with the obliquely descending posterior margin, which in many cases forms a moderately developed wing, but in other cases may be altogether absent. Young shells are often symphynote at the upper posterior angle. Beaks slightly swollen and moderately convex, somewhat elevated above the hinge-line, placed more or less anterior to the middle of the shell. Beak-sculpture (Marshall, 1890, figs. 15, 18, as of *A. lewisi*) normally distinct and rather heavy, consisting of four to five (rarely six) bars, of which the first and second are concentric, while the following are distinctly double-looped, with a sharp re-entering sinus between the loops. The anterior loop is broadly rounded, while the posterior is angular, narrower, and characteristically elevated, so as to form a distinct tubercle. However, there is great variability in the beak-sculpture, chiefly with regard to the development of the sinus and the tubercle. The former may be shorter or longer, often so long as to reach the preceding bar; often the bar is weak at the sinus, so that a notch is formed, the anterior and posterior loop being higher than this part. The tubercles may be more or less distinct, and sometimes also the posterior end of the anterior loop (close to the sinus) is tubercular, so that a double row of tubercles appears to be present, radiating from the beaks. In partly eroded beaks, often only the tubercles are preserved.

Shell gently swollen in the middle and toward the beaks, but swelling very variable, sometimes rather flattened on the disk. Posterior ridge indistinct, greatest diameter of the shell about the middle. Posterior slope slightly compressed, often elevated and winged at the upper posterior angle.

Epidermis yellowish, greenish, to brownish and blackish. Rays indistinct as a rule; in large specimens (and often also in younger ones), there is no trace of rays on the disk. In other cases there are traces of green rays, but they are never very distinct, and, when present, generally obliterated by the concentric color-

[90] Simpson (1900, p. 644) gives, with ??, southeastern Pennsylvania, but this is surely incorrect.

pattern. The latter consists of concentric bands of lighter and darker color, largely corresponding to growth-periods. Upon the lighter bands the rays are sometimes visible. However, very often there are one to three more distinct, dark green to black rays upon the posterior slope, which are best visible in transmitted light. In many specimens, chiefly in the common creek-form, the epidermis is uniformly blackish.

Hinge edentulous, forming a practically straight line, with only the faintest trace of a light undulation under the beaks. Beak-cavity shallow or moderate. Dorsal muscle-scars faint, situated in the beak-cavity. Nacre white, as a rule, silvery, bluish white, or cream-color, rarely pinkish, generally highly iridescent, with blue, purple, and greenish reflections. In some cases it is more distinctly reddish (salmon to rusty), but this is pathological (see below under *salmonia*).

There is a difference in the shape of the shell of the two sexes, but this is very slight, and not always present. In the females, and chiefly in the larger ones, the shell is more swollen in the posterior middle portion of the disk, just in front of the indistinct posterior ridge, in the region where the marsupium is located. This swelling sometimes renders the lower margin more curved and slightly prominent behind the middle. In extreme cases the shell is even slightly depressed in front of the swelling. In young and half-grown shells this shape is not noticeable, and even older shells do not always show it. Where it is distinctly developed, it can be safely taken for an indication of the female sex, but not all females have this character. It also should be said, that in the typical (creek-) form, this sexual difference is much less evident, than in the form of quiet water (*gigantea*).

	L.	H.	D.
Size: 1. Linesville, Cat. No. 61.845 (largest on hand)	128 mm.	70 mm.	44 mm.
2. Edinboro, Cat. No. 61.3648 (♀ gravid)	126 "	62 "	44 "
3. Waynesburg, Cat. No. 61.4729 (♀)	123 "	68 "	40 "
4. Cochranton, Cat. No. 61.3661 (♀ gravid)	118 "	68 "	39 "
5. Jamestown, Cat. No. 61.3659 (♂)	105 "	61 "	41 "
6. Waynesburg, Cat. No. 61.4729 (♂)	91 "	52 "	33 "

Soft parts (See Ortmann, 1912, p. 292). *Glochidia* figured by Lea, Obs. VI, 1858, Pl. 5, figs. 32–34 and Surber, 1912, Pl. 3, fig. 45. Surber's measurements are: 0.41 × 0.42, while I gave: 0.36 × 0.37 mm.

Breeding season: Gravid females have been frequently found from August 6 to November 12, and again on May 22. This species seems to discharge very early in spring (April). May 22 seems to be an exceptionally late date.

Remarks: This is a very variable species, for which a great number of specific names has been introduced, chiefly by Lea. The typical form (of which *ovata*

Lea, *lewisi* Lea, *salmonia* Lea, *harpethensis* Lea simply are synonyms) is a shell preferably inhabiting small creeks. It is chiefly characterized by its rather elongated, subovate shape, with rather flat valves, by the comparative solidity of the shell, its dark (greenish to blackish) color, and the nodulous character of the beak-sculpture. The posterior end of the shell generally is narrowed, and the posterior point is moderately elevated above the base line; and there is hardly a wing (however, this is sometimes indicated in the young). Yet all these characters are variable, and certain extreme forms are found under peculiar conditions of environment, so that they are to be regarded as ecological variations, which turn up, within the range of the species, wherever the proper conditions are found. A number of them have received names; but these names should not be used as varietal names, since the forms designated by them have no defined geographical areas. They certainly are not "subspecies" in the strict taxonomic sense. I shall mention here some of these "forms," as far as they are found in Pennsylvania, with the express understanding, that I regard them only as individual variations, or at the utmost as special reactions to peculiar environmental conditions, which are not regionally restricted.

Anodonta grandis forma *salmonia* (Lea) (Obs. II, 1838, Pl. 14, fig. 41).

This is an unqualifiedly typical *grandis*, with the nacre peculiarly discolored (reddish, from pale salmon to deep rusty red), and at the same time the nacre becomes rough by the formation of small pustules and granulations. That this is due to an infection by a parasite (a distomid) is now generally conceded (see Wilson & Clark, 1912*a*, p. 47), and consequently the name *salmonia* has no taxonomic standing, and might better be entirely dropped.

In Pennsylvania, such diseased forms are rather frequent in the northwestern corner of the state (headwaters of Beaver system, and small tributaries of the upper Allegheny), but are absent in the southwestern section. Sometimes traces of this disease are found in pond- and lake-forms. At certain localities, practically all individuals are more or less infected with this parasite.

Anodonta grandis forma *gigantea* (Lea) (1834) (Simpson, 1914, p. 420).

This is the form found in small, muddy pools, where it lives deeply buried in black muck. It is distinguished from the creek-form by its larger size, thinner, and higher and less elongated shell, and generally by more vivid color (yellowish and greenish concentric bands, and more distinct traces of rays). However, this form also is very variable, even in the same pond, and it passes insensibly into the creek-form. In ponds more elongated specimens are often found, and in creeks specimens from quiet and muddy pools distinctly incline toward the pond-form. Specimens from ponds often also possess a rather thick shell.

This form is rather scarce in Pennsylvania. My supply of it comes chiefly from a pond (old branch of Allegheny River) at Harmarville, Allegheny Co. But other specimens are at hand from an artificial ice pond at Edgeworth, Allegheny Co., and from a pond at Idlepark, Westmoreland Co., formed by the cutting off of a part of Loyalhanna River by the railroad. Probably this form will turn up in other ponds of the western part of the state.

					L.	H.	D.	
Size: 1.	Harmarville,	Cat. No.	61.4742 (♂)		149 mm.	90 mm.	51 mm.	(largest)
2.	do.	"	"	61.3667 (♀ gravid)	148 "	88 "	56 "	
3.	do.	"	"	61.4742 (♂)	116 "	68 "	49 "	
4.	do.	"	"	do. (♀ gravid)	109 "	66 "	40 "	
5.	do.	"	"	do. (♂)	107 "	64 "	43 "	
6.	do.	"	"	do. (♂)	93 "	58 "	31 "	

Comparing these measurements with those of the creek-form, given above, it is clearly seen that this form stands very close to the type, but grows larger, and is relatively somewhat shorter and higher. It also is distinctly thinner in the shell. It is in this form, that I have best recognized the sexual differences of the shell.

In addition there are other local forms in our region, and such are found chiefly in the lakes of the glacial area in northwestern Pennsylvania. The following deserve special mention; but should not bear distinct names, since they are only special reactions to special environment, and probably entirely inconstant.

Conneaut-lake-form A. Resembles in shape and the thin shell the form *gigantea,* but is only half as large, and the epidermis has a peculiar light green to pale brown color. I have only a few specimens, which I collected on gravelly bottom on the north east shore of Conneaut Lake in from three to four feet of water.

Conneaut-lake-form B. Like form A in color (light green), but much more elongated and subelliptical (not subovate). This form in shape looks almost like *A. marginata* Say (= *lacustris* Lea), but traces of the beak-sculpture of *grandis* are plainly seen. I have only a single specimen, which was collected by Mr. D. Stewart, and I do not know particulars about the ecological conditions, except that it comes from somewhat deeper water. L. 58 mm., H. 32 mm., D. 17 mm.

Conneauttee-lake-form. A much elongated form, like form B of Conneaut Lake, with very thin shell, but epidermis darker, green to brownish black. As in form B from Conneaut Lake, the beaks appear much anterior in consequence of the posterior elongation of the shell. The typical *grandis*-sculpture of the beaks is well developed.

	L.	H.	D.
Size: 1.	115 mm.	55 mm.	39 mm.
2.	76 "	40 "	22 "
3.	50 "	25 "	15 "

I obtained five specimens of this form in the black muck of Conneauttee Lake, Edinboro, Erie Co. In the outlet of the lake (Conneauttee Creek) the creek-form of *A. grandis* was more or less typically developed.

Finally, it should be mentioned, that there are often specimens among typical *A. grandis*, which are more swollen, thus approaching the var. *footiana* (to be discussed below). Such specimens sometimes are rather frequent at certain localities, chiefly so in the uppermost Shenango River, at Linesville, Crawford Co., and these forms are truly transitional toward var. *footiana*. It also should be emphasized that the form in Conneaut Creek, at West Springfield, Erie Co. (tributary to Lake Erie) is the typical creek-form of *A. grandis*.

Anodonta grandis behaves in Pennsylvania exactly as elsewhere. Over the wide range of this species we have a great tendency to form local races and ecological forms, which in many cases have received names of their own, without

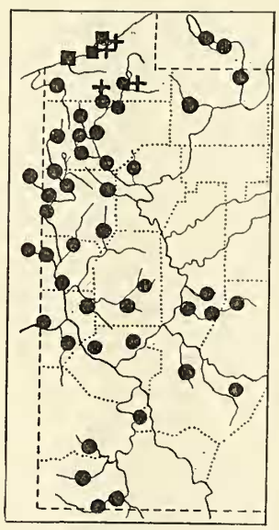


Fig. 14.

● *Anodonta grandis.*
■ *Anodonta grandis footiana.*
\+ *Anodonta ohiensis.*

deserving them. I cannot go further into detail, since my material of the extra-limital forms is not at all sufficient. But it is clearly seen that in Pennsylvania as elsewhere this species is protean, accommodating itself to a variety of conditions, and assuming different characters in shape and thickness of shell, in color, and in size. It does not seem to reach in our state the extreme size recorded from other parts (Baker, 1898*a*, p. 53, L. 171 mm.). However, one character generally

remains constant, or varies only within narrow limits, that is the beak-sculpture, which in well-preserved individuals is always double-looped and tubercular.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio-drainage:

Smiths Ferry, Beaver Co. (D. A. Atkinson).[91]
Raccoon Creek, New Sheffield, Beaver Co.
Ice pond, Edgeworth, Allegheny Co. (G. H. Clapp) (forma *gigantea*).
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).[92]
Brush Creek, Celia, Beaver Co.
Glade Run, Zeno, Butler Co.
Bonnie Brook, East Butler, Butler Co.
Wolf Creek, Grove City, Mercer Co.
Mahoning River, Hillsville, Lawrence Co.
Neshannock Creek, Volant, Lawrence Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Shenango River, Sharpsville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.

Allegheny-drainage:

Pond, Harmarville, Allegheny Co. (forma *gigantea*).
Beaver Run, Delmont, Westmoreland Co.
Pond, Idlepark, Westmoreland Co. (D. A. Atkinson) (forma *gigantea*).
Crooked Creek, Rosston and Southbend, Armstrong Co.; Creekside, Indiana Co.
Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).
Sandy Creek, Sandy Lake, Mercer Co.
French Creek, Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Sugar Creek, Cooperstown, Venango Co. (E. P. Spencer).
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co. (special forms, see above).
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Conneauttee Creek, Edinboro, Erie Co.
Conneauttee Lake, Edinboro, Erie Co. (special form, see above).
Leboeuf Creek, Waterford, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.

Monongahela-drainage:

Monongahela River, Westmoreland Co. (G. A. Ehrmann).
Ten Mile Creek, Amity, Washington Co.
South Fork Ten Mile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.

[91] Not recorded upon the label whether from the Ohio or from Little Beaver Creek, probably from the latter.

[92] Rhoads (1899) does not give this species from Wampum, and H. H. Smith also apparently overlooked it, since the specimen, upon which our record is founded, was discovered among duplicates of *Strophitus edentulus*.

Lake Erie-drainage:

Conneaut Creek, West Springfield, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Black Creek, Chili, Monroe Co., New York (R. H. Santens).
Creek at North Fairfield, Huron Co., Ohio (O. E. Jennings).[93]
Ten Mile Creek, Lucas Co., Ohio (C. Goodrich).[94]
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Toledo, Lucas Co., Ohio (C. Goodrich).
St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Raisin River, Adrian, Lenawee Co., Michigan (C. Goodrich).
Big and Little Whitefish Lake, Pierson, Montcalm Co., Michigan (Miss M. O'Malley).[95]

Ohio-drainage:

Chautauqua Lake (R. Foerster): Bemus Point (D. R. Sumstine), Griffith Landing (Miss B. A. Ortmann), Celeron (P. E. Nordgren), Chautauqua Co., New York.[96]
Conotton Creek, New Hagerstown, Carroll Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
Redfield, Perry Co., Ohio (Juny collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Lewistown Reservoir, Logan Co., Ohio (C. Goodrich) (head of Big Miami).
Wabash River, Fort Recovery, Mercer Co., Ohio (C. Goodrich).
Gravel pit, near Bluffton, Wells Co., Indiana (E. B. Williamson).[97]
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson) (Mrs. E. Courtney).[98]
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Licking River, Farmer, Rowan Co., Kentucky.
Fleming Creek, Pleasant Valley, Nicholas Co., Kentucky.

[93] Intergrading toward var. *footiana*.

[94] Intergrading toward var. *footiana*.

[95] A form, compressed like typical *grandis*, but having a peculiar, light-colored epidermis.

[96] I have many specimens, all representing a peculiar local race, greatly resembling *A. benedictensis* Lea; small (maximum L. 90 mm.), and not quite as short as *benedictensis*. Most specimens much abraded upon posterior slope. Color light green to light brown, but not blackish. Beak-sculpture of typical *grandis*-character. Call (1885) reports *A. footiana* from this lake, but my specimens are *not* this.

[97] Intergrading toward var. *footiana*.

[98] A special form resembling *gigantea* in outline, but rather swollen, like *footiana*, and with the beak-sculpture of typical *grandis*. Epidermis light greenish to brown. One specimen almost like specimens from Tippecanoe Lake, recorded below under *footiana*. Call (1900) gives *footiana* from Eagle (= Winona) Lake; Norris (1902) records *grandis* from Winona as well as Pike and Center Lakes, and does not mention *footiana*.

Tennessee-drainage:

Mountain Fork Flint River, New Market, Madison Co., Alabama (H. E. Wheeler).[99]

Western and southwestern localities:

Flat Creek, Sedalia, Pettis Co., Missouri (W. J. Utterback) (typical!).

Wakarusa River, Lawrence, Douglas Co., Kansas (R. L. Moodie) (typical!).

Sabine River, Logansport, De Soto Parish, Louisiana (L. S. Frierson).[100]

Lake Providence, East Carroll Parish, Louisiana (Juny collection).[101]

The Carnegie Museum possesses additional material, chiefly from southern and southwestern localities, but these are local forms or races, with which I am not familiar, and so I do not discuss them here. There are specimens at hand from the Alabama-drainage, in part labeled *A. hallenbecki* Lea by Walker. They are very close to *A. grandis*, and if they are actually *hallenbecki*, this name should also probably become a synonym of *A. grandis*.

Distribution and Ecology in Pennsylvania (See fig. 14): As has been mentioned above, the typical *A. grandis* is a form characteristic of smaller creeks. It decidedly avoids the larger rivers, and is not found at all in the Ohio and Allegheny, and from the Monongahela only a single individual is on record. This holds good also farther down the Ohio. In the tributaries, however, it is not rare, and becomes most frequent in the smaller headwaters.

In these creeks it prefers quiet pools and eddies, often below riffles, where it sticks in fine sand and mud. Occasionally it is found in riffles, but then probably washed out of deeper and more quiet places. Yet it is to be seen that the typical form by its somewhat stronger shell is adapted to a stronger flow of water, since even in the quiet pools of small streams a stronger current may prevail during periods of high water.

Under these conditions this species is found rather uniformly over western Pennsylvania, and goes eastwards to Warren, Indiana, and Westmoreland Cos. But it is also capable of living in rather different surroundings, namely in ponds and lakes. But we have seen that special forms develop under these conditions. However, with the exception of a few glacial lakes, this environment is not often found in western Pennsylvania, and there is a remarkable lack of ponds in the southwestern part of the state. Thus the pond forms are rather scarce in our region, as may be seen from the records given above, and we notice that they often turn up in isolated ponds (Harmarville, Edgeworth, Idlepark), where there is apparently no connection with streams inhabited by it. This has been observed

[99] A large, thick-shelled form, corresponding wonderfully well with Lea's original figure of *gigantea* (Obs. II, 1838, Pl. 1, fig. 1).

[100] A specimen absolutely indistinguishable from typical creek-forms of Pennsylvania, possibly not quite as thick-shelled as the average.

[101] Very much like the typical *gigantea*.

elsewhere, and its presence in such ponds can be explained only by the assumption, that exceptional means of dispersal are available, presumably transport by aquatic birds. This is also suggested by its distribution across the northwestern section of our state, where it seems as if it had gone across country, not following the streams. This, however, requires further investigation. It should also be pointed out that it is very remarkable that these factors, if acting at all, did not act in an eastward direction across the Alleghenian divide; and that this species is entirely missing in the Atlantic-drainage, although it approaches the divide very closely in Indiana and Westmoreland Cos. But this holds good only for Pennsylvania, and is different in New York (see below).

General distribution: Type locality, Fox River of Wabash River, Indiana (Say).

According to Simpson (1900, p. 644),[102] the range covers the "entire Mississippi system; the upper St. Lawrence-drainage; Red River of the North; Lake Winnipeg; Manitoba; southwest Texas" (he also with doubt mentions southeastern Pennsylvania, but this should be cancelled). This is certainly a correct general statement. But the exact boundaries of this species are yet largely ill-defined. In western Pennsylvania we apparently have part of the northeastern boundary of the range, and it here coincides practically with the divide between the interior basin and the Atlantic-drainage. However in New York state this is different, for here this species passes over into the Atlantic-drainage of the Hudson as well as the St. Lawrence River (see DeKay, 1843; Dewey, 1856; Marshall, 1895; Baker, 1898*b*). In part in its eastward advance, it seems to have used the route of the Erie canal, reaching Albany County, and has here invaded the territory of the eastern *A. cataracta*. Its relation to this latter species in this region (western and central New York) has never been closely studied, and on account of the great resemblance of these two species it is very likely that they have often been mistaken for each other. In this region *A. grandis* (generally known under the name of *A. lewisi*) is found chiefly in streams and in some smaller lakes, and it does not go into the large lakes. The same seems to be true all along the northern boundary of its range, and, as soon as the great lakes are reached, it turns into the var. *footiana*. In Pennsylvania, it goes up to the divide, and it is even in Conneaut Creek, a tributary of Lake Erie; but it is *not in* the lake.

Generally in the region of the divide, intergrades are found between the two varieties. Farther south *grandis* prevails, and finally is the only form in existence.

[102] To Simpson belongs the credit of having reduced the number of species of *Anodonta* to reasonable limits, and he has to a large extent worked out the synonymy of this species; but I hardly think that he has gone far enough, and believe, that some "species" admitted by him, will finally fall as synonyms under *A. grandis*.

In the Tennessee-drainage it is extremely rare, but certainly extends into northern Alabama. It is also very rare in the Cumberland-drainage, but has been reported by Wilson & Clark (1914) from ponds at Clarksville, Montgomery, Tennessee, and from Stones River, in Rutherford Co., Tennessee.

In the southwestern part of its range this species seems to become more decidedly a pond- or lake-form. Call (1900) makes the statement that in Indiana it is found in the ponds along the Ohio and Wabash, and that it occurs in the rivers in the northwestern part of the state, that is to say, in smaller streams; this corresponds well with what we have observed in Pennsylvania. But west of the Mississippi pond-forms prevail, and assume special shapes, which I cannot discuss here, for they require much more detailed study (compare Wheeler, 1918, p. 121).

Anodonta grandis footiana (Lea) (1840).

Anodonta grandis footiana (Lea) Simpson, 1914, p. 422.

Plate X, figs. 3, 4.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 202.

Characters of variety: According to Baker (1898*a*, pp. 51 and 53), this variety differs from *Anodonta grandis* by the greater inflation of the shell, chiefly in the anterior and umbonal region, and by the finer beak-sculpture, which consists of only four bars (while there are five in *A. grandis*).

This is the most concise statement of the differences of the two forms that has ever been made. But with regard to the number of the bars in the beak-sculpture it is to be remarked that in the light of my material, this is quite variable (from four to six bars in *footiana* as well as *grandis*), but with a stronger tendency toward the smaller figure in *footiana*.

In other respects *A. grandis footiana* behaves much like *A. grandis*, and varies greatly in shape (more or less elongated), thickness, and color (from yellowish and greenish to brownish and reddish); it lacks the dark green and blackish tints found so often in *grandis*. Rays are generally entirely missing. The size is inferior to that of *grandis*.

		L.	H.	D.	
Size: 1.	Beach Pool G., Cat. No. 61.4182	122 mm.	65 mm.	48 mm.	(largest at hand)
2.	do. " " do.	115 "	57 "	45 "	long form.
3.	do. " " do.	100 "	52 "	38 "	
4.	Beach Pool E. & F., Cat. No. 61.4181	98 "	53 "	41 "	
5.	do. " " do.	95 "	49 "	37 "	
6.	"Big Bend," Cat. No. 61.4188	107 "	67 "	43 "	short form.
7.	do. " " do.	93 "	53 "	37 "	

Soft parts: As far as studied, identical with those of *A. grandis,* but gravid females have never been found, and thus the *glochidia* and the *breeding season* are unknown. However, the fact that the specimens, collected in May, June, and July, were not gravid, indicates that the "interim" falls in these months, as is the case in *A. grandis,* and thus probably the breeding season will be about the same.

Remarks: I regard this as a geographical race of *A. grandis,* which replaces the latter in the St. Lawrence-drainage, and chiefly in the Great Lakes. It is, however, not a "good species," for south of the lakes, and passing somewhat beyond the divide, into the Ohio-drainage, there is a region, where true intergrades are found (in Pennsylvania, Ohio, Indiana, and Illinois). Some of these intergrades, standing nearer to *grandis,* have been recorded under *grandis* (see above). And further, even in Lake Erie, the form *footiana* does not always preserve its typical characters, becoming sometimes more flattened (specimens from the lagoon at Waldamer Park, and from ponds at mouth of Elk Creek, and occasionally elsewhere), and having heavier beak-sculpture.

As regards the beak-sculpture, it is essentially of the *grandis*-type in so far as it consists of four or five (sometimes six) bars, of which the third to the sixth are distinctly double-looped, the loops separated by a sharp, re-entering sinus. Within this sinus the bar is generally lower, sometimes almost effaced, so that it represents a notch, on either side of which the anterior and posterior loop appear elevated.[103] However, the posterior loop of *footiana,* which has the same angular and narrow shape as in *grandis,* is not so much thickened, and is not so distinctly tuberculiform, and altogether the beak-sculpture is less heavy, finer, and sharper than in *grandis.* The notch-like shape of the sinus, forming generally an interruption of the bar, shows that this form should be placed under *A. grandis,* although by the delicacy of the sculpture it distinctly inclines toward *A. cataracta.*

In Lake Erie (in Pennsylvania), *A. grandis footiana* shows two extremes of development of the shape of the shell, which are connected, however, by intergrades, and are, according to my observations, distinctly dependent on the ecological conditions under which they live.

The most abundant form (among my material) is rather elongated, and closely corresponds in the general outline to Lea's *maryattana* (Obs. III, 1842, Pl. 20, fig. 45), but it is not so excessively and abruptly swollen. In its typical development this form is also characterized by a thin shell, and a peculiar, rusty-brown color, which is especially intense at and near the umbos, passing into brownish

[103] In some cases, the fifth, and chiefly the sixth bar (if this is present) have the sinus less sharp, resembling only an undulation: this is a variation, which I have never distinctly observed in *A. grandis.*

and yellowish brown toward the lower margin (alternating according to the growth-periods). There is no, or very little, green present, and the rays upon the posterior slope, if visible at all, are brownish black. According to my experience this form is characteristic of the lagoons and beach-pools of Presque Isle, where it is quite abundant, and very uniform in character.

The other form is less elongated, higher and shorter, sometimes squarish, with a very straight hinge-line, having a sharp anterior and posterior angle. Its shell is generally more solid, and its color is distinctly greenish, often rather light green, but passing into light brown, rarely into rusty. Its growth-rests are distinct and rather regular, and the rays upon the posterior slope are dark green. This is the form prevailing in Presque Isle Bay, chiefly on its north-shore, so called "Big Bend." Some of these short, squarish forms resemble to a degree *A. benedictensis* Lea (Obs. I, 1834, Pl. 16, fig. 48; and DeKay, 1843, Pl. 18, fig. 235), but I do not think they should be called by this name,[104] for there are intergrades with the elongated form of the beach-pools. These intergrades are frequently found associated with the normal (quadrate) form, and do not have the quadrate shape, but are more or less subovate, much resembling the original figure of Lea's *footiana* (Obs. III, 1842, Pl. 20, fig. 44). The specimens collected in ponds at the mouth of Elk Creek are all of this subovate form, with the typical *footiana* outline, and at the extreme western end of Presque Isle Bay in quiet and rarely disturbed water this ovate form is also present. In the lagoon at Waldamer Park I found specimens, which are more elongated, and thus approach the beach-pool form, but they have green (not rusty) epidermis.

It is evident that the squarish, thick-shelled form of the surf-beaten northern shore of Presque Isle Bay passes gradually into the elongated, thin-shelled form of the lagoons and beach-pools; and that it should be regarded as an ecological variation of *A. grandis footiana* (with which it agrees in the inflated beaks), and not as a form of *benedictensis*.

The various forms of *footiana* are distinguished from *A. cataracta* by the swollen and inflated beaks. Although *cataracta* has sometimes a rather inflated shell, the beaks are always low, and not so prominent as in *footiana*.

[104] *A. benedictensis* comes originally from Lake Champlain, and has been reported from other lakes in New York. The Lake Chautauqua-form of *A. grandis*, mentioned above, might be regarded as a dwarf form of it, and also the form from Lake Erie (Sterki, 1907*a*, p. 394; Walker, 1913, p. 22). Mr. Walker (according to a communication in a letter) considers the quadrate form and straight hinge-line as the chief characteristics of his *benedictensis*, and admits that this differs from the true *benedictensis* in being more inflated. All this fits the present form.

Localities in Pennsylvania, represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, and beach-pools of Presque Isle, and lagoon at Waldamer Park, Erie, Erie Co.

Pond at mouth of Elk Creek, Miles Grove (North Girard), Erie Co.

Other localities represented in the Carnegie Museum:

Lake Ontario, Braddock Bay, Manitou Beach, Monroe Co., New York (R. H. Santens).[105]
Lake Erie, Port Dover, Norfolk Co., Ontario, Canada (C. Goodrich).
Lake Erie, Sandusky Bay, Cedar Point, Erie Co., Ohio (O. E. Jennings) (normal).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich) (young specimens).
Cedar Creek, Jerusalem Township, Lucas Co., Ohio (C. Goodrich).
Marsh, north of Toledo, Lucas Co., Ohio (C. Goodrich).
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids, Lucas Co., Ohio (C. Goodrich).[106]
Grand Reservoir, Mercer Co., Ohio (C. Goodrich).[107]
Silver Lake, Clark Co., Ohio (Hartman collection).[108]
Tippecanoe Lake, Kosciusko Co., Indiana (E. B. Williamson).[109]
Lake Huron, Port Huron, St. Clair Co., Michigan (N. M. Grier).
Black Lake, Muskegon Co., Michigan (Exch. Alabama Museum).
Big Bass Lake and Au Sable Lakes, Lake Co., Michigan (C. Goodrich).
Douglas Lake, Cheboygan Co., Michigan (H. B. Baker).
Muskoka Lake, Bala, Muskoka Co., Ontario, Canada (A. S. Daggette).
Lake Helen, Nipigon, Ontario, Canada (O. E. Jennings).
Lake Superior, Nipigon Straits, St. Ignace Island, Ontario, Canada (O. E. Jennings).
Blackwater River, Jellicoe, Ontario, Canada (O. E. Jennings) (Tributary of Lake Nipigon).
Long Lake, Longuelac, Ontario, Canada (O. E. Jennings).

In 1914, Dr. Jennings collected a form in Lake Nipigon (Orient Bay), which, in shape and beak-sculpture, is a true *A. grandis*, but has a peculiar rough epidermis. I have not yet been able to identify this.

Distribution and Ecology (See fig. 14): *Type locality,* Winnebago, Winnebago Co., Wisconsin (Lea).

In Pennsylvania this form is restricted to Lake Erie, and although individuals resembling it have been found in the uppermost Shenango, they were associated

[105] An interesting set of sixteen specimens, containing individuals inflated like typical *footiana*, some much more flattened, almost like typical *grandis*, with intermediate stages between these. Outline of the shell elongated-ovate, shorter or longer, like the creek-form of *grandis*, beak-sculpture more like *grandis*. Color light green to gray or brownish green. These are truly intergrades.

[106] A special (river-) form, heavy shelled, greenish, with rather heavy beak-sculpture. Considerably inflated at the beaks. A link in the chain of intergrades.

[107] Inflated like *footiana*, but in outline resembling the *gigantea* type.

[108] A typical elongate-subovate, greenish *footiana*. The specimen was labeled as given, but I cannot find a Silver Lake in Clark Co., but there are places of this name in Logan and Summit Cos.

[109] Wabash-drainage. A peculiar large form, resembling the form of *grandis gigantea* from Winona Lake, but more swollen, and with the beak-sculpture of *footiana*.

with typical *grandis*, and should be classed with them. In Lake Erie, this form is found, as has been stated, under various ecological conditions, but not in the open lake. It is present on the north shore of Presque Isle Bay, where there is, at times, a considerable surf, and lives here in from one to five feet of water. It has also been brought up by the "sand-sucker" from a depth of ten to fifteen feet. It prefers a bottom of pure sand or fine gravel, either bare, or covered with a growth of rushes (*Juncus americanus*). Many specimens on the north shore of the bay are much abraded, and apparently worn by the surf. Toward the western end of the bay, it is found upon the sandy "flats," among rushes, and at the extreme western end on a bottom, which consists of a mixture of sand and mud; in this section, the water is rather quiet, there is surf only during easterly winds, and this is broken and checked by the *Juncus americanus* formation, which runs far out into the bay. Further, this species in a special form inhabits the numerous lagoons and beach-pools of Presque Isle, which are rather shallow, and have a bottom of fine sand, often covered with more or less fine vegetable mud. It occurs also in the large and deep lagoon at Waldamer Park (base of Presque Isle), and I also found it in a pond cut off from the mouth of Elk Creek, on sandy-gravelly bottom. In Pennsylvania, this is distinctly a lake- and pond-form.

Lake Erie and the smaller lakes of the state of Michigan seem to be the metropolis of this form. The largest number of locality records are at hand from Michigan, due to the fine work of Walker (1898, see map of distribution, Pl. 1). Northwards it goes here as far as Chippewa Co. (Winslow, 1917) and Marquette Co. (South of Lake Superior), and Lake Gogebic, Ontonagon Co. (Ruthven). It is also in the lakes and bays of Isle Royale in Lake Superior (Walker, 1909, p. 294), and the Carnegie Museum possesses it from the region of Nipigon, on the North shore of Lake Superior. The most extreme locality in a northwestern direction is Souris River, Manitoba (Hudson Bay-drainage) (Dawson, 1875).

From Wisconsin it is known only from the type locality (Winnebago). Southward, it crosses over into the Mississippi-drainage in northern Ohio (Sterki, 1907*a*), northern Indiana (Call, 1896*a* and 1900),[110] and northern Illinois (Cook, Lake, Kane, McHenry Cos.) (See Baker, 1906, p. 73).

From Lake Erie eastwards and northeastwards, we have a number of records in western New York (Marshall, 1895), as far as Ottawa River, Canada (Call, 1885). However, some of these are doubtful, as for instance, Call's record from Chautauqua Lake, according to him the only locality in the Mississippi basin.

[110] As to *grandis* and *footiana* in Winona Lake (See footnote 98 on p. 144). Our specimens from this lake are nearer *grandis*. The form from Tippecanoe Lake in our collection is more like *footiana*; Wilson & Clark (1912*a*, p. 47) call this form: *grandis*, "of a more inflated type."

The form found in this lake, represented in the Carnegie Museum by numerous specimens, is a small race of *A. grandis*, possibly to be placed with *benedictensis*, but not with *footiana*.

A. grandis footiana belongs preëminently to the St. Lawrence system, and has a wide range in it. It crosses over into the Mississippi as well as the Hudson Bay drainages, but only very slightly, and in the former it intergrades with *A. grandis*.

Anodonta cataracta Say (1817).[111]

Anodonta cataracta Say. Simpson, 1914, p. 386.

Plate X, fig. 5; Plate XI, fig. 1.

Records from Pennsylvania:

Haldeman, 1844 (Lancaster Co.).

Gabb, 1861 (Mill Creek, Milltown; Wissahickon Creek and Schuylkill River, Philadelphia, Germantown and League Island, Philadelphia Co.).

Lea, 1867 (Schuylkill, Delaware River, and League Island, Philadelphia) (*tryoni*).

Bruckhart, 1869 (Lancaster Co.).

Hartman & Michener, 1874 (Schuylkill River, Chester Co.).

Pilsbry, 1894 (York Furnace, York Co.).[112]

Schick, 1895 (Delaware and Schuylkill Rivers, Fairmont Park, League Island, Philadelphia; Germantown, and Canal at Manayunk, Philadelphia Co.; Munckinipattus Creek, Glenolden, Delaware Co.).

Marshall, 1895 (Tributaries of Genesee River, Potter Co.;[113] Juniata River).

Ortmann, 1909*b*, p. 205.

Caffrey, 1911 (Lehigh Canal and ponds, Bethlehem, Northampton Co.).

Characters of the shell: This species is very close to *A. grandis*, and the only reliable difference is in the beak-sculpture, and even this is a difference rather of degree of development than of type. The general character of the beak-sculpture is the same in both species (double-looped), but while in *A. grandis* the two loops are sharply separated by a sinus, which is generally depressed (notch-like), and while the posterior loop is tuberculiform, in *A. cataracta* the bars of the beak-sculpture, which are also slightly more numerous (five to seven) are uniform in elevation, and in the sinus they are not appreciably lower than in front and behind of it, so that no tubercles are formed. These differences have properly been pointed out by Marshall (1890, p. 188, 189). In the light of my material I have only to add, that the first two bars are simply concentric, and that those following are

[111] Not 1816, see p. 9.

[112] Pilsbry's (p. 30) "*A. subcylindrica* Lea" is this species. I have seen the specimens so labeled in the Philadelphia Academy of Natural Sciences.

[113] This locality should be confirmed.

double-looped, but in the last (sixth and seventh) the sinus is often not sharp, but represented merely by a gentle undulation. There is a good deal of variation, chiefly in the number of bars, but also in the sharpness of the sinus, which may be acute or more or less blunt.

In other characters the shells of the two species are much alike, but as a rule *A. cataracta* inclines more toward the elongated shape, although it also possesses comparatively short and high forms. In the elongated pond-forms, another difference is noted in the position of the posterior end, which is more elevated above the base-line, so that the lower margin of the shell is more strongly convex, its posterior part running more decidedly upwards. But this character is not observed in the creek-forms. Also the posterior "wing" is generally more distinct in *A. cataracta*, although often very low.

On the average the color of *A. cataracta* is brighter green than in *A. grandis*. It is light to dark green, rarely shading into brownish and blackish, often very brilliant, with concentric lighter and darker bands, and the dark green rays are also more distinct upon the disk; though there are specimens which do not show any rays. The broad rays of the posterior slope are often strongly developed and broadened, so as to render the whole posterior slope blackish green.

In this species as in its allies, the female sex is sometimes indicated by a swelling of the valves posteriorly to the middle, but not all females exhibit this character.

	L.	H.	D.	
Size: 1. Flinton, Cat. No. 61.3637 (largest on hand)	128 mm.	72 mm.	45 mm.	pond-form
2. do. " " 61.3636	125 "	65 "	44 "	
3. Lockhaven, Cat. No. 61.4173 (♀ gravid)	112 "	56 "	42 "	
4. Tioga, Cat. No. 61.4171 (♀ gravid)	85 "	46 "	27 "	creek-form
5. Avondale, Cat. No. 61.4167	86 "	42 "	31 "	
6. York Haven, Cat. No. 61.4727 (♂)	84 "	47 "	28 "	
7. Schuylkill, Philadelphia, Cat. No. 61.816	87 "	50 "	33 "	*tryoni*-type

These measurements do not express the maximum size, and considerably larger specimens are on record.

Soft parts practically identical with *A. grandis* (See Ortmann, 1912, p. 293). *Glochidia* figured by Lefevre & Curtis, 1910, p. 97, fig. C, and 1912, p. 146, fig. C.

Breeding season: Conner says (1907 and 1909) that this species is gravid from September to May, and that the interim falls in June, July, and August. I have collected gravid females on July 23, 1908; August 19, 1909; Aug. 21, 1908; Aug. 24, 1909; Sept. 5, 1909; March 19, 1911; April 24, 1909.

Of these dates, July 23 is surely an exceptional case (only one specimen was gravid among a large number). The dates in August mark the beginning of the

breeding season, and are earlier than Conner's records. Some of the specimens collected on April 24 were found discharging. This would establish the breeding season as lasting from August to May, a condition, which is much like that seen in *A. grandis*. It seems, that the glochidia are discharged rather early, for I never found any charged females in May.

Remarks: There still might be some lingering doubt, as to whether *A. cataracta* is specifically distinct from *A. grandis*. However, I have never seen any specimens, which might be called intergrades, and wherever I have examined the beak-sculpture, it has always been possible to distinguish these two species by this character. Nevertheless they are closely allied, and there is no question that *A. cataracta* is the eastern representative of the western *A. grandis*. The two forms are geographically well separated. It is true that in New York the ranges do overlap, but I think this is due to a secondary, postglacial expansion of the two species into the glacial area. During glacial times, they undoubtedly were completely separated (Ortmann, 1913, pp. 325, 363–365). Walker's opinion, expressed incidentally, that *cataracta* is closely allied to the European *A. cygnea*, and might be a co-immigrant with *Margaritana margaritifera* from Europe, cannot be maintained. Compare also Latchford (1914, p. 10).

A rather strong argument for the specific distinctness of *A. grandis* and *cataracta* is, as I believe, their different behavior or reaction to environment. Both possess a creek- and a pond-form, but while the reaction to the pond-environment in *A. grandis* is to develop a large, high and comparatively short shell (*A. grandis gigantea*), in *A. cataracta* a more elongated shell is the result, with a "rostrate" posterior end. This latter characteristic shape of the shell is never found distinctly in *A. grandis*. On the other hand, the creek-form of *A. grandis* is subovate, with the anterior end broad, and the posterior narrowed, while the creek-form of *A. cataracta* is rather subelliptical, with the anterior and posterior ends generally rather equally narrowed.

The short and high type of shell, so common in *A. grandis*, is much rarer in *A. cataracta*, but it is present. Lea's "species" *williamsi*, *virgulata*, and *tryoni* represent this. They may be described as follows.

A. williamsi. (*Type locality* Lower Potomac.) High and short, with better developed posterior wing, so that the upper and lower margins of the shell become subparallel. Sometimes the posterior wing may be so high that the posterior part of the shell appears higher than the anterior (ovate, with anterior end narrower).

A. tryoni. Closely resembling *A. williamsi*, but with the posterior wing not

so high, so that the shape becomes short-ovate, with the posterior end narrower.

A. virgulata. (*Type locality* North Carolina.) In shape intermediate between *A. williamsi* and *A. tryoni*, but with brighter coloration and more distinct rays. This is, according to Simpson (1914, p. 388) a southern form of *A. cataracta.*

Such short and high shells seem to be rather scarce in Pennsylvania, but the *tryoni*-type occurs in the larger rivers (Delaware and Schuylkill), and might be called characteristic of this environment.

The thickness of the shell is also variable in *A. cataracta;* the pond-forms being generally thinner, while the creek-forms are thicker. *A. cataracta* is also quite variable in the convexity of the valves; and there are more compressed and more inflated shells, both in ponds and creeks. The inflation, if present, is restricted to the disk, and does not extend to the umbos, and forms having inflated beaks, like *A. grandis footiana*, are not known among the variations of *A. cataracta*, except possibly in the South, among the *virgulata*-type, in which there seems to be a tendency in this direction.

The various forms of *A. cataracta*, described above, are all connected by intergrades, and they seem to be special reactions to special environmental conditions, although we are not in all cases sure what are the essential features of the environment, which are active. In the Schuylkill Canal I found, for instance, shells resembling the creek-form (but thin-shelled), where we should rather expect the pond-form. But here the bottom of the canal was somewhat stony, with very little mud, and it is quite possible, that in this case the character of the bottom was all important. Specimens from Echo Lake, Monroe Co., more closely resemble the creek-form. Since these various forms turn up all over the range of the species, they are to be regarded simply as variations, not as varieties. The idea, that they may be species is entirely excluded.

I should add here a few words about a peculiar, distorted form, received from Mr. C. H. Conner from the Delaware River, Newbold, Gloucester Co., New Jersey. There are five specimens, resembling in general characters the *tryoni*-type, but all possessing a peculiar radial rib, running from the beaks toward the lower margin of the shell, and in front of the rib the shell is somewhat compressed. It seems as if the growth of the shell in its anterior part had been checked or retarded. The specimens look decidedly like cripples, and I take them for such, yet it is remarkable that a number of specimens showing the same deformation should be found at the same locality.

Localities in Pennsylvania represented in the Carnegie Museum:

Delaware-drainage:

Delaware River, Penn's Manor, Bucks Co. (young, approaching *tryoni*).

White Clay Creek, Avondale, Chester Co. (typical creek-form).

Crum Creek, Delaware Co. (Hartman collection) (creek-form, but thin).

Schuylkill Canal, Manayunk, Philadelphia Co. (thin-shelled creek-form).

Schuylkill River, Philadelphia (Hartman collection) (labeled *tryoni*, and representing this type).

Wissahickon Creek, Roxboro, Philadelphia Co. (creek-form).

Little Neshaminy Creek, Grenoble, Bucks Co. (creek-form).

In a dry pond of Mahoning Creek, Lehighton, Carbon Co. (pond-form).

Echo Lake, Monroe Co. (G. H. Clapp, donor).

Susquehanna-drainage:[114]

Conewago Creek, York Haven, York Co. (creek-form).

Penn Canal, Selinsgrove, Snyder Co. (lake-form).

Chemung River, South Waverly, Bradford Co. (creek-form, remarkably light green, found in riffles).

Mill-race of Crooked Creek, Tioga, Tioga Co. (typical creek-form).

Ponds near paper-mill, Lockhaven, Clinton Co. (all typical pond-form).

Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson) (typical pond-form: from an old dam in the creek; some of the younger ones incline toward the creek-form).

Potomac-drainage:

Conococheague Creek, Greencastle, Franklin Co. (creek-form, unusually thick-shelled; from riffles in water heavily charged with lime); Scotland, Franklin Co. (creek-form, dwarfed).

Great Tonoloway Creek, Thompson Township, Fulton Co. (creek-form).

Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:

Eastwicks Park, Grays Ferry, Philadelphia (S. R. Roberts).

Wister Dam, Germantown, Philadelphia Co. (W. Stone).

Oxford Dam, Guinea Creek,[115] Woodbourne, Bucks Co. (H. W. Fowler).

Porters Lake, Pike Co. (S. N. Rhoads) (headwaters of Bushkill Creek, to Delaware).

Harvey Lake, Luzerne Co. (C. H. Conner) (W. Stone) (Harvey Creek, to North Branch Susquehanna).

On New Jersey side of Delaware:

Pond near Delaware River, Delanco, Burlington Co., New Jersey (H. A. Pilsbry).

Other localities in the Carnegie Museum:

Monmouth, Kennebec Co., Maine (Woods collection) (typical creek-form).

Charles River, Cambridge, Middlesex Co., Massachusetts (Mrs. L. D. Thompson) (creek-form).

Lake Ontario, Braddock Bay, Manitou Beach, Monroe Co., New York (R. H. Santens).[116]

[114] A dead and broken shell was seen, but not taken, in the Juniata River (Raystown Branch) at Ardenheim, Huntingdon Co.

[115] No such name is on the topographical map; the creek at Woodbourne is a branch of Mill Creek.

[116] One specimen, collected together with specimens of *A. grandis footiana*, mentioned above. It has the typical shape of the creek-form of *A. cataracta*, and differs from the others in the beaks, which are not inflated. Beak-sculpture poorly preserved, but apparently of the *cataracta*-type.

Backwater of Hudson River, Milton, Ulster Co., New York (H. H. Smith) (young, intergrading from pond-form to *tryoni*-type).

Binghamton, Broome Co., New York (H. H. Smith).[117]

Culvert Pond, Sussex Co., New Jersey (J. F. L. Raeschen) (creek-form, but thin-shelled).

Delaware-Raritan Canal, Aquaeduct, near Princeton, Mercer Co., New Jersey (young, *tryoni*-type).

Delaware River, Fish House and North Cramer Hill, Camden Co., New Jersey (from both places the creek-form); Newbold, Gloucester Co., New Jersey (C. H. Conner) (cripples).

Potomac River, Washington, D. C. (Hartman collection) (*tryoni*-type).

South Branch Potomac River, Romney, Hampshire Co., West Virginia (chiefly creek-form, but some, from quiet pools, inclining to pond-form).

South River (upper Shenandoah), Waynesboro, Augusta Co., Virginia (thin-shelled creek-form from a quiet pool).

Paper-mill, Salem, Forsyth Co., North Carolina (Holland collection) (*virgulata*-type).

Ashburn Creek, Mecklenburg Co., North Carolina (Hartman collection) (*virgulata*-type).

Distribution and Ecology in Pennsylvania (See fig. 15): In Pennsylvania this species belongs to the Atlantic-drainage. It has indeed been reported by Marshall

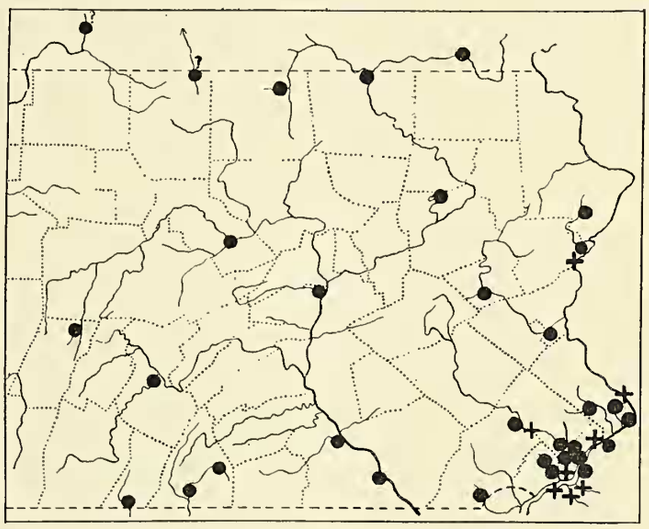


Fig. 15.

● *Anodonta cataracta.* + *Anodonta implicata.*

(1895) from the headwaters of the Genesee River in Potter Co., but this requires confirmation. When I collected in the Genesee River and Cryder Creek, at Genesee, Pennsylvania, I did not find any *Anodontas*.

As the records show, *A. cataracta* is found in the drainages of all three Atlantic rivers, the Delaware, Susquehanna, and Potomac. It apparently is most abundant in the lowlands and on the Piedmont Plateau, but goes up considerably towards

[117] The label says: "Chemung River," but Binghamton is not on this River; the specimen has all the earmarks of a pond-shell.

and into the mountains, farthest in the Susquehanna, where it ascends to Cambria Co., west of the Allegheny Front. Here it is closest to the divide, and it is interesting to note, that on the other side in the Ohio-drainage of Indiana and Westmoreland Counties, the creek- and pond-forms of *A. grandis* turn up.

I collected the pond-form in rather small (artificial) ponds, with very muddy bottoms, and also, but more rarely, in quiet pools in creeks. I obtained the creek-form most commonly, but it is rather erratic in distribution. It seems to avoid the larger rivers (although found under special conditions in the estuary of the Delaware). It favors smaller rivers (Chemung) and creeks. Here it lives on gravelly bottoms, in more or less strongly flowing water (even in riffles), or in more quiet pools in gravel, sand, or mud. The short and high form (*tryoni*-type) seems to prefer large rivers with muddy bottoms, but I have not observed it often enough to express a final opinion.

Probably this species has a more general distribution in eastern Pennsylvania, and the pond-form might especially be found in many other ponds (and lakes): these localities, however, are often not easily accessible, and it is hard to locate this shell in them.

General distribution: Type locality, not given by Say, but probably is eastern Pennsylvania.

Simpson (1900) reports this species from "Lower St. Lawrence-drainage; streams draining into the Atlantic south to North Carolina."

In the St. Lawrence-drainage, it has been reported from Lake Ontario (Hamilton Bay, Marshall, 1895, and Toronto, Latchford, 1914), and this is confirmed by a specimen in the Carnegie Museum. Farther down it is known from various points along the St. Lawrence, and also from the Lake Ontario-drainage in western New York. But there is some doubt whether all the records given by Marshall (1895) from this section actually refer to this species. At any rate two of these records: Buffalo Creek in Erie Co. (to Lake Erie), and Ischua Creek, Cattaraugus Co. (to Allegheny River) appear to me very doubtful, and should be confirmed. In this region, indeed, it seems, that the ranges of *A. grandis* and *A. cataracta* overlap, and on account of the great resemblance of these two species, it is quite possible, that some of the identifications are not correct. This question deserves special study.

On the Atlantic side this species goes northward to Maine, as is shown by one of our localities, and it has been reported by Jackson (1908) North Haven Island, Knox Co. and Lermond (1909) Cumberland Co. Walker & Coolidge (1908) give it from Keene, Cheshire Co., New Hampshire, Adams (1842) from

Middlebury, Addison Co., Vermont, and Marshall (1895) from Benson, Rutland Co., Vermont. It is also present in Rhode Island (Carpenter, 1890), and is frequent in the western and central parts of Massachusetts (Gould-Binney, 1870). Thence southward it becomes rather common, but south of Pennsylvania records become scarce. No positive localities are at hand from Maryland. From Delaware it has been mentioned by Rhoads (1904), and the localities from Virginia and North Carolina are few. I have found it in the Potomac-drainage in West Virginia and Virginia. According to Simpson it goes only to North Carolina, but there are old records given by Lea for his *virgulata* and *williamsi* from Georgia, so that the southern boundary of this species becomes obscure; in addition a number of closely allied forms or species have been described from the southern states, the standing of which remains to be investigated.

We must regard *A. cataracta* as a form characteristic of the northern section of the Atlantic Coastal Plain and the Piedmont Plateau, from which center it has spread more or less toward the Allegheny Mountains, but without crossing the divide; and from which it has widely spread, probably in Postglacial times, to the northeast and north, and also slightly northwestwards, reaching New England and the lower St. Lawrence basin, where it has met the eastward expansion of the western *A. grandis* (See Ortmann, 1913*a*).

Anodonta implicata Say (1829).

Anodonta implicata Say, Simpson, 1914, p. 391.

Plate XI, figs. 2, 3.

Records from Pennsylvania:

Lea, 1838 (Schuylkill River, Philadelphia) (as *A. newtonensis*).
Gabb, 1861 (League Island, Philadelphia).
Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Marshall, 1895 (Philadelphia).
Ortmann, 1909*b*, p. 206.

Characters of the shell: Large, elongated, similar in shape to the pond-form of *A. cataracta*, but with the posterior end not so elevated; rather thick-shelled, and noticeably thickened along the lower anterior margin (from the middle forwards). Nacre more or less reddish, or salmon-color.

It is also said that the shell is more inflated (subcylindrical) than in *A. cataracta*, and that the color of the epidermis is lighter (yellowish) and has no rays. This, however, probably is not always the case. Marshall (1890) says, that the beak-sculpture is also different, with the sinus less developed, being gentle in the

earlier, and missing in the later bars. This holds good in at least one of the specimens before me. The rough epidermis is also given as a character, as distinguished from the shining *cataracta*, but this is not confirmed by my material.

		L.	H.	D.
Size: 1.	Yardley, Cat. No. 61.3639	75 mm.	41 mm.	26 mm.
2.	do. " " do.	74 "	40.5 "	25 "

These are the only specimens of considerable size collected by myself, and they are hardly more than half the maximum size attained by this form.

Soft parts and *glochidia* unknown.

Breeding-season: According to Conner (1909) from September to May (like *cataracta*). Lefevre & Curtis (1912, p. 141) enumerate this species under the forms with long breeding-season.

Remarks: This is a form the taxonomic standing of which is as yet obscure and I myself have not been able to form a clear conception of it. According to previous authors, the characters given above are essential, but they apply only to the adult shell, and I am unable to say much about the young shell. The smallest shells I have seen are those I collected in the Delaware at Shawnee (Length: 58, 46, 41, and 39 mm.). Of these the largest shows traces of the thickening at the lower anterior margin, while the smaller ones do not. These shells have the epidermis rather yellowish, and the nacre has a good deal of salmon-color, and therefore I think they actually represent this species. All other shells I have seen are larger, and show the character of the thickening of the margins well-developed. The best account of this shell has been given by Gould (Binney, 1870, p. 180), but even here it is admitted that the young shells are difficult to distinguish from *A. fluviatilis* (= *cataracta*).

The Carnegie Museum possesses only eight specimens, to which I should apply the name *implicata*. One (without locality) is from the Hartman collection, and is certainly this form. It is large (L. 122 mm.), elongate (H. 67), and swollen (D. 56). Its epidermis is shining (not rough) and of a yellowish-olive to light brown color, without any rays. The beak-sculpture is as described by Marshall. The valves also show the characteristic thickening along the anterior lower margin, and the nacre is pale pinkish. Another specimen was sent to me by C. H. Conner (Timber Creek, Gloucester, New Jersey, just south of Newton Creek, Camden Co., the type locality of Lea's *newtonensis*). It is 103 mm. long, 49 high, and 41 in diameter. Thus it is rather elongated, swollen, and subcylindrical. The epidermis is blackish brown (not pure black as in the figure of *newtonensis*), the beaks are eroded, and the beak-sculpture gone. The thickening of the margin is present, and the nacre is pinkish or salmon.

In addition, I have collected two specimens in the Delaware River in Bucks Co., which are the specimens of which the measurements are given above, and to them must be added the four young ones, mentioned above, taken at Shawnee, Monroe Co. All these are much smaller, and are not at all swollen nor subcylindrical. The color of the epidermis is greenish with light brown or yellowish concentric bands, without distinct rays, or else nearly uniformly light brown, darker behind. The larger ones show the thickening of the shell, and all have a more or less distinct tint of salmon in the nacre.

In the collections of the Philadelphia Academy of Natural Sciences I have seen comparatively few specimens, hardly more than a dozen. The thickening of the margin of the shell is always present, often also the pinkish color of the nacre and the inflation of the valves. The color of the epidermis ranges from greenish yellow to blackish.

Localities represented in the Carnegie Museum:

Delaware River, Yardley, Bucks Co.; Shawnee, Monroe Co., Pennsylvania.
Timber Creek, Newbold, Gloucester Co., New Jersey (C. H. Conner).

Localities represented in the Philadelphia Academy:

Schuylkill River (I. Lea).
Thorps Mill-Pond, Branchton, Philadelphia (S. R. Roberts).
Delaware River, Torresdale, Philadelphia Co., Pennsylvania (S. R. Jacob).
Channel of Delaware River, about 600 feet off New Jersey shore, in 35–45 feet depth, muddy bottom, "East of North end of Little Tinicum Island" (L. Woolman).[118]

Distribution and Ecology (See fig. 15): *Type locality*, Pond, Danvers, Essex Co., Massachusetts (Say).

Simpson (1900) gives the range of this species as: "St. Lawrence-drainage; north to Lake Winnipeg; south in streams flowing into the Atlantic to Virginia." I am unable to substantiate this, and the localities on record only in part confirm Simpson's statement. The question also arises, whether all the citations recorded actually refer to this species. At all events, I seriously question the record "Lake Erie, Port Dover, Canada" (Marshall, 1895). South of New Jersey and Pennsylvania I know of no reliable records whatever.

In Pennsylvania this species has only been found in the neighborhood of Philadelphia, in the Schuylkill and Delaware Rivers, and in ponds. It occurs also on the opposite side of the Delaware in New Jersey. My own localities are farther up the Delaware. Not a single specimen has ever turned up in the Susquehanna

[118] Little Tinicum Island has no north end; probably what is meant is "south of east end." The locality is off Billingsport, Gloucester Co., New Jersey.

and Potomac drainages. Altogether it seems to me, that this form is more northern in its distribution, and the majority of localities are from New York, Connecticut, and Massachusetts, in which direction it goes as far as Maine (Lermond, 1909). Generally it is reported as living in ponds, but sometimes also in rivers. The locality in the deep channel of the Delaware (35 to 45 feet depth), given above, is quite interesting and possibly suggestive. Further studies on this species are very desirable. (See Ortmann, 1913*a*, p. 363.)

ANODONTA OHIENSIS Rafinesque (1820).

Anodonta imbecillis SAY. SIMPSON, 1914, p. 395; *Lastena ohiensis* (RAFINESQUE) UTTERBACK, 1916, p. 109.[119]

Plate XI, fig. 4.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 195 and 202.

Characters of the shell: Shell small, at the utmost of medium size, very thin. Outline subelliptical, rather elongate, rounded anteriorly, narrowed and somewhat pointed behind. Lower margin gently convex, less so in the posterior part, sometimes almost straight in the middle. Upper margin straight, forming a more or less distinct angle with the obliquely descending posterior margin, and in general this angle is elevated to form a wing, which is rarely entirely obliterated. Beaks depressed, and not at all elevated above the hinge-line. In young shells the beaks slope down obliquely (roof-like) from the hinge-line; in older, more swollen shells, they are nearly or entirely horizontal. Beaks placed anterior to the middle of the shell. Beak-sculpture fine, weak, and irregular, consisting of four to six subconcentric ridges, of which the later ones have a faint sinuation, which is only wavy, and does not form an angle. Often this sinus is represented only by an interruption of the bar.

Shell of young specimens very slightly swollen, or even compressed; in older ones it becomes more inflated, and assumes in extreme cases an almost subcylindrical shape. Posterior ridge very indistinct, rounded; greatest diameter of the shell about in the middle. Posterior slope more or less compressed and elevated into the wing of the upper posterior angle.

Epidermis lighter or darker green, often beautifully grass-green, grayish, brownish, or yellowish near the beaks, with concentric, darker growth-rests, and

[119] I object to the use of the generic name *Lastena* for this species. It is not the type of Rafinesque's subgenus *Lastena*, and a type for this genus was not designated until Simpson (1900, p. 654), selected *lata* Rafinesque for it. It might possibly be desirable to generically separate this species from the other species treated in this paper under *Anodonta*, but in this case, a new name should be found.

with dark green, more or less distinct, rays on the whole disk. Two or three dark green to blackish rays generally well developed upon the posterior slope.

Hinge edentulous, forming a straight line, or with a faint indication of a wave under the beaks. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Adductor muscle-scars indistinct. Nacre blueish white, silvery, iridescent, sometimes slightly cream-color toward the beak-cavities.

This species being a hermaphrodite does not show any sexual differences in the shell.

	L.	H.	D.
Size: 1. Erie, Cat. No. 61.3291	83 mm.	41 mm.	28 mm.
2. Waterford, Cat. No. 61.4178	67 "	32 "	24 "
3. do. " " do.	56 "	27 "	16 "
4. Edinboro, Cat. No. 61.3290	48 "	25 "	12 "

The largest specimen represents about the maximum size attained by this species. Generally it remains considerably smaller (Length between 50 and 60 mm.).

Soft parts (See Ortmann, 1912, p. 291). *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 36); Ortmann (1911, Pl. 89, fig. 13); Surber (1912, Pl. 1, fig. 2). Surber's measurements are: 0.31 × 0.29 (longer than high), while I gave: 0.30 × 0.31 mm. (higher than long).

Breeding-season: My dates for gravid females are: June 2, 1908 (eggs); July 12, 1910 (discharging); Sept. 14, 1909 (eggs and glochidia); May 21, 1908 (glochidia and discharging); May 22, 1909 (glochidia and discharging); May 24, 1909. Surber (1912, p. 7) gives March, June, July, August, and September as months when gravid individuals are present. From Arkansas I have gravid specimens collected by Wheeler on February 20, 1913; June 14, 1911; July 17, 1911; and in November, 1911.

This is undoubtedly a *bradytictic* form, and according to the above dates, it apparently breeds "all the year round," *i.e.*, the succeeding breeding seasons overlap in June and July, but probably not in the same individual.

Remarks: A well-marked species, which is easily recognized by its shape and color. As far as my material permits a conclusion, it varies very little, and the variations are restricted to the proportional length of the shell and its degree of obesity; the latter of which in part depends on age. The color of the epidermis is also somewhat variable, being lighter or darker green, but specimens from the same locality are generally very uniform.

Localities in Pennsylvania represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Horseshoe Pond, and beach-pools on Presque Isle, Erie, Erie Co.
Leboeuf Creek (outlet of lake), Waterford, Erie Co.

Conneauttee Lake, Edinboro, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Miami and Erie Canal, Lucas Co., Ohio (C. Goodrich).

Ohio-drainage:

Tuscarawas River, Ohio (Holland collection).
Scioto River, Columbus, Franklin Co., Ohio (H. H. Smith).
Wabash River, Bluffton, Wells Co., Indiana (C. Goodrich).

Tennessee-drainage:

Paint Rock River, Paint Rock and Princeton, Jackson Co., Alabama (H. H. Smith).

West of Mississippi:

James River, Galena, Stone Co., Missouri (A. A. Hinkley).
Lawrence, Douglas Co., Kansas (R. L. Moodie).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Big Deceiper Creek, Gum Springs, Clark Co., Arkansas (H. E. Wheeler).
Black Bayou, Victoria Co., Texas (D. A. Atkinson).

Alabama-drainage:

Black Warrior River, Lock 11, Tuscaloosa, Tuscaloosa Co., Alabama (H. H. Smith).
Pond at Holt, Tuscaloosa Co., Alabama (H. H. Smith).
Beaver Creek and Canoe Creek, St. Clair Co., Alabama (H. H. Smith) (Coosa-drainage).
Othkalooga Creek, Calhoun, Gordon Co., Georgia (H. H. Smith) (Coosa-drainage).

Atlantic-drainage:

Greenfired Mill, Wilmington, New Hanover Co., North Carolina (G. H. Clapp donor).

Distribution and Ecology in Pennsylvania (See fig. 14): This species is restricted to the northwestern section of our state (Erie Co.), and is principally found in Lake Erie, where it inhabits the sandy shores of Presque Isle Bay and the beach-pools at the eastern end of Presque Isle. At two places I discovered it in the Ohio-drainage, in the headwaters of French Creek, in Conneauttee Lake, in the black muck of this lake; in the other case, at the outlet of Leboeuf Lake, on partly muddy bottom, in slack water, and partly on gravelly bottom and on shell marl in more strongly flowing water.

Baker (1898*a*) records it from muddy bottoms in creeks, small rivers, and ponds, and Scammon (1906) calls it a lover of quiet water and muddy or somewhat sandy banks. This agrees well with my observations.

The peculiar distribution in Pennsylvania resembles somewhat that of certain other species, which are found only in the northwestern part of our state.

General distribution: Type locality, Ohio River (Rafinesque).

Simpson (1900) says: "Entire Mississippi-drainage area; southern Michigan; North Carolina to Georgia; southwest to Matamoras, Mexico." This indicates a

very wide range, but it should be qualified somewhat. It is actually found over large parts of the Mississippi-drainage, but records are missing from the tributaries South of the Ohio. In the Cumberland-drainage, it is only found in ponds near Clarksville, Montgomery Co., Tennessee (Wilson & Clark, 1914); and in the Tennessee-drainage it goes up to northern Alabama, but seems to be missing in East Tennessee. Northward it passes into the lake-drainage in Wisconsin (Milwaukee, Lapham, 1860), Illinois (Baker, 1906), Michigan (Walker, 1898), Ohio (Sterki, 1907*a*; Walker, 1913), and advances northeastwards to northwestern Pennsylvania and western New York, reaching, by way of the Erie Canal, Herkimer Co., New York (Lewis, 1860; Marshall, 1895). In the upper Mississippi, it ascends to southeastern Minnesota (Grant, 1886; Holzinger, 1888).

Westward it occurs in the tributaries of the Mississippi in Kansas (Scammon, 1906), Arkansas, Oklahoma, and northwestern Louisiana (Vaughan, 1893; Frierson, 1899). It is frequent in the streams flowing into the Gulf in Texas (Singley, 1893), reaching Matamoras in Mexico, according to Simpson. In addition it is known from the Alabama-drainage, going thence into Georgia and the Carolinas. This section of the range is represented in the Carnegie Museum by specimens from Alabama, Georgia, and North Carolina, and is probably connected westward with the localities in Louisiana.

Genus Anodontoides Simpson (1898).

Ortmann, 1912, p. 293; Simpson, 1914, p. 466.

Type *Anodonta ferussaciana* Lea.

Only one species is known, which, however, has several varieties, one of which is found in Pennsylvania.

Key to the Forms of Anodontoides.

a_1. Shell compressed, and less elongated.. ..... *A. ferussacianus.*

a_2. Shell more swollen, more elongated, thus approaching the subcylindrical shape. *A. ferussacianus buchanensis.*

Anodontoides ferussacianus (Lea) (1834).

Anodontoides ferussacianus (Lea) Simpson, 1914, p. 467.

Plate XI, fig. 5.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 195.

Characters of the shell: Shell small to medium in size, thin. Outline subelliptical or subovate, moderately elongate, rounded anteriorly as well as posteriorly,

more rarely somewhat narrowed behind. Lower margin gently and rather regularly curved, often nearly straight in the middle. Upper margin gently curved, and curved down into the posterior margin, forming, or not forming a slight angle, without a distinct wing. Beaks convex, but not much swollen, only slightly elevated above the hinge-line, placed more or less anterior to the middle. Beak-sculpture consisting of three to four subconcentric, fine, and rather sharp ridges, the first two or three placed obliquely to the direction of the hinge-line (bent up behind), the following ones showing a more or less distinct angle. On the posterior slope there are several fine radiating lines, indicating additional bars, obliterated on the disk. Double-looped structure of the bars is entirely absent (See beak-sculpture of var. *buchanensis*, as figured by Marshall, 1890, figs. 13, 14).

Shell more or less compressed to moderately swollen, greatest convexity upon the posterior ridge, which is rounded and not sharply marked. Posterior slope slightly compressed.

Epidermis light green to olive, grayish, brownish or blackish, generally grayish, yellowish, or light brown towards the beaks, mostly with numerous narrower or wider, dark green rays, which, however, are often indistinct, and disappear in old shells on account of the general darkening of the epidermis. Upon the posterior slope, there may, or may not, be a few darker, broader rays. In addition, the epidermis is often concentrically banded, the growth rests being marked by blackish color.

Hinge practically edentulous, straight or slightly downward curved anteriorly. In front of the beaks it is more or less (often very indistinctly) incurved, and here shows rudiments of cardinals in the shape of small tubercles, swellings, or mere irregularities. Beak-cavity shallow. Dorsal muscle-scars faint, in front part of beak-cavity. Adductor muscle-scars faint.

Nacre bluish white, sometimes discolored by greenish or creamy tints toward the beak-cavity; more or less iridescent, chiefly towards the posterior end.

Shell of male and female hardly different. Although Baker (1898*a*, p. 73) says that the shell of the female is more inflated posteriorly (*i.e.*, at and in front of posterior ridge) this inflation is not always present. If it is distinctly developed, we may safely assume that we have to deal with a female, but many females do not possess it.

	L.	H.	D.
Size: 1. Greenville, Cat. No. 61.3294	73 mm.	38 mm.	28 mm.
2. do. " " do.	68 "	38 "	19 "
3. Shenango, Cat. No. 61.4207 (♀)	71 "	38 "	25 "
4. do. " " do.	62 "	35 "	18 "

This species grows somewhat larger in some western streams.

Soft parts (See Ortmann, 1912, p. 294). *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 35) (immature), and Ortmann (1911*b*, Pl. 89, fig. 12).

Breeding-season: Records for gravid females are at hand for: August 7, 1908; Aug. 8, 1908; Aug. 26, 1911; Sept. 13, 1917; Sept. 27, 1909; Oct. 10, 1907; and May, 1908. *Glochidia* have been found in September, October, and May; and on May 14 discharging specimens have been seen.

Thus this species is bradytictic. The breeding season begins in August and lasts till May.

Remarks: This is a species, which has a rather indifferent, generally subelliptical shape, without any striking features. Externally it looks like a small *Anodonta*, and the thickness of the shell is also much like that of *Anodonta*. Moreover the shape of the shell is rather variable, being sometimes longer, or shorter, and more or less compressed. If the beaks are well-preserved, there is no mistake about its identity, since the beak-sculpture is quite peculiar and characteristic. Eroded shells may be distinguished from *Anodonta* by the hinge-line, which is not so straight.

In general shape *Strophitus edentulus* is often much like this species, and, when the beaks are eroded, the two species are sometimes hard to tell apart. But they may be distinguished by the thinner shell of *Anodontoides*, the interior of which is blueish white and strongly iridescent, while in *Strophitus*, especially in older specimens, the nacre is more thickened toward the beak-cavity, and there turns pure white, creamy, or even salmon-color, and is not so iridescent. Further in *Strophitus* the rudiments of the cardinal teeth are more distinct, and the hinge is more incurved in front of the beaks. When the beaks are preserved, *Strophitus* is distinguished by the heavier beak-sculpture. Of course, the soft parts, chiefly those of the female, when it is gravid, are entirely different in these two species.

The convexity of the valves varies greatly in *Anodontoides ferussacianus*, and becomes sometimes rather great, thus approaching the shape of the var. *buchanensis* (see below). Such specimens turn up now and then among normal ones, and at a few localities more frequently, as for instance, in Conneaut Lake. Some shells from this locality (and also from the outlet of the lake) might safely be called *buchanensis;* while others, found with them, have the normal, more compressed shape; similar conditions prevail in the uppermost Shenango River, at Linesville. We actually have here the intergrades between the normal form and the variety.

It should be noted, that the form from Conneaut Creek (tributary to Lake Erie) is the normal form, not the Lake Erie form (*buchanensis*).

Localities in Pennsylvania represented in the Carnegie Museum:

Shenango River, Sharpsville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.; Hadley, Mercer Co. (D. A. Atkinson).
Randolph Run, Hartstown, Crawford Co.
Conneaut Lake and Conneaut Outlet, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. &. L. Ellsworth).
French Creek, Meadville, Crawford Co.
Conneaut Creek, West Springfield, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Tributary of Lake Ontario, Cobourg, Northumberland Co., Ontario, Canada (D. Stewart).
St. Lawrence River, Clayton, Jefferson Co., New York (Miss A. H. Robinson).[120]
Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Cedar Creek, Jerusalem Township, Lucas Co., Ohio (C. Goodrich).
Ten Mile Creek, Silica, Lucas Co., Ohio (C. Goodrich).
Silver Creek, Williams Co., Ohio (C. Goodrich).
Otter Creek, Monroe Co., Michigan (C. Goodrich).
Raisin River, Tecumseh, Lenawee Co., Michigan (C. Goodrich).

Ohio-Mississippi-drainage:

Tuscarawas River, Ohio (Holland collection).
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).
Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Fleming Creek, Pleasant Valley, Nicholas Co., Kentucky.
Cumberland River, Orby, Bell Co., Kentucky.

Western:

Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Smoky Hill River, Logan Co., Kansas (C. W. Gilmore).
Lodgepole Creek, Julesburg, Sedgwick Co., Colorado (G. H. Clapp, donor).
Big Thompson Creek, Loveland, Larimer Co., Colorado (A. Koenig).

Distribution and Ecology in Pennsylvania (See fig. 16): This species is found exclusively in the northwestern section of our territory, mainly in the headwaters of the Beaver system, and of French Creek. In addition it occurs in Conneaut Creek, a tributary of Lake Erie. Thus it obviously falls into the same category as some other species before mentioned. Apparently its metropolis in our state is the upper Shenango, where it is abundant, for instance at Linesville and in Pymatuning Creek. It has never been found below Sharpsville, just below the mouth of Pymatuning Creek. In French Creek proper it is rare (only one found at

[120] Dwarf, pale race, possibly the var. *modestus* (Lea).

Meadville), while it is rather frequent in Conneaut Outlet and in the lake itself. This peculiar feature will be discussed elsewhere. It suffices to mention here that

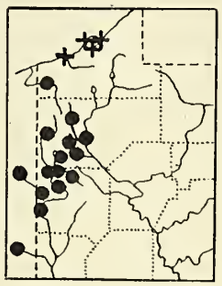


Fig. 16.

● *Anodontoides ferrussacianus.*
+ *Do. feruss. buchanensis.*

all these systems (Beaver, Conneaut, French Creek) have been either naturally or artificially closely connected in the past.

Wherever I found this species in abundance it preferred comparatively quiet parts of the creeks, with little or no current, and with sandy-gravelly bottoms, with some admixture of mud. It also occurs in lakes, as for instance Conneaut Lake, and exhibits here the tendency to become more inflated, approaching thus the var. *buchanensis*. In Conneaut Lake it is found chiefly on sandy bottom at the south end of the lake, but also elsewhere in gravel. It seems to be averse to larger streams with strong currents and rough bottoms.

Baker (1898*a*) says that it is a species frequenting muddy bottoms.

General distribution: Type locality, Ohio River, Cincinnati, Ohio (Lea).

According to Simpson this species is found generally in the Mississippi-drainage area; in the St. Lawrence system; the Red River of the North; the Saskatchewan River; and doubtfully in Connecticut (according to Linsley, 1845, at Whitneyville, New Haven Co.).

In the east its range certainly extends into New York state, as far as the Hudson River and the headwaters of the Susquehanna and Delaware systems (Marshall, 1895),[121] and it is frequent in the St. Lawrence-drainage in a form which is typical (see our specimens from the Genesee River). I have it also in rather typical development from a tributary on the Canadian side of Lake Ontario, and it has been reported from Montreal and Ottawa. Farther west, its northern boundary is uncertain, but it surely advances rather far northward, as is shown by the localities given by Walker (1898) for Michigan (Charlevoix, upper Penin-

[121] But it is not found in Pennsylvania in these rivers.

sula), by localities in Wisconsin and Minnesota, and the Canadian range given by Simpson. Southward it is well distributed over the states of Ohio to the Ohio River (Sterki, 1907*a*), Indiana (Call, 1896*a* and 1900), and Illinois (Baker, 1906; Forbes & Richardson, 1913). It has not been found in the Ohio above Cincinnati, and south of the Ohio. It does not occur in southwestern Pennsylvania and in the headwaters of the Monongahela and in the Little Kanawha in West Virginia. But it turns up in the Big Kanawha-drainage, and is found in the Licking system in Kentucky. It is known from the Cumberland (Wilson & Clark, 1914) (also Carnegie Museum), and is very rare in the uppermost Tennessee system (Powell River). (This will be discussed elsewhere.)

Westward *A. ferussacianus* goes across the Mississippi, where it is found in South Dakota, Iowa, and Kansas, advancing here, in the Kansas River-drainage, farther westward than any other shell (Decatur Co., Scammon, 1906, and Logan Co., Carnegie Museum). In addition, the Carnegie Museum has received material representing this species from the state of Colorado (Platte River-drainage), which extends its western range here to the foot of the Rocky Mountains.

Farther south this species has not been reported, and in general the range is rather northern.

Anodontoides ferussacianus buchanensis (Lea) (1838).

Anodontoides ferussacianus subcylindraceus (Lea) Simpson, 1900, p. 660; *Anodontoides ferussacianus buchanensis* (Lea) Simpson, 1914, p. 469.

Plate XI, fig. 6.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 202.[122]

Characters of variety: This form differs from the typical *ferussacianus* by the more convex valves and the more elongated outline, which renders the whole shell more nearly subcylindrical.

			L.	H.	D.
Size: 1.	Presque Isle,	Cat. No. 61.1577	82 mm.	39 mm.	33 mm.
2.	do.	Cat. No. 61.3295	81 "	38 "	28 "
3.	do.	" " do.	75 "	38 "	29 "
4.	do.	" " do.	66 "	31 "	26 "
5.	do.	" " do.	65 "	31 "	24 "

Soft parts not different from those of the typical form. *Glochidia* not observed by myself. Surber (1912, Pl. 3, fig. 43) figures them; his measurements are:

[122] Pilsbry (1894, p. 30) records " *Anodonta subcylindrica* Lea " (sic!) from York Furnace, York Co. The specimens thus labeled in the Philadelphia Academy are *Anodonta cataracta* Say. (See above.)

0.33 × 0.33, while my measurements for the typical form (1912, p. 294) are: 0.32 × 0.32 mm.

Breeding season: Not observed. According to Surber gravid specimens have been found in September and October.

Remarks: The subcylindrical, more elongated shape of the shell is the only reliable character by which this form may be recognized; and even this is not always equally well-developed. Lake Erie specimens may incline toward the normal form, and, on the other hand, more swollen individuals may turn up in the Ohio-drainage, chiefly in the lake environment.

Special attention should be directed to the fact that in Conneaut Creek, tributary to Lake Erie, the typical form is found; and parallel to this is the fact that likewise from tributaries of the lake in northwestern Ohio and southeastern Michigan this form is at hand.

In Lake Erie, principally in the beach-pools and ponds of Presque Isle, the var. *buchanensis* is also characterized by its color. The latter is not greenish, but is reddish brown, generally beautifully reddish chestnut near the beaks, shading to dull dark brown and blackish upon the disk and toward the margins. In most cases rays are very obscure or entirely absent, with the exception of a few indistinct blackish ones upon the posterior slope. This color, however, certainly is only a local, environmental effect. It resembles much the color observed in the beach-pool form of *Anodonta grandis footiana*, but is more intense, and, moreover, not all specimens from Presque Isle have it. From the bay I have specimens, which are distinctly green, with distinct rays, and hardly any rusty brown. Such specimens agree very closely with specimens from Conneaut Lake, and the connection of the variety with the type is thus complete.

Localities represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, and beach pools of Presque Isle, Erie, Erie Co., Pennsylvania.
Pond at mouth of Elk Creek, Miles Grove (North Girard), Erie Co., Pennsylvania.
Lake Erie, Port Dover, Norfolk Co., Ontario, Canada (C. Goodrich).
Lake Erie, Buffalo, Erie Co., New York (Hartman collection).
Raisin River, Adrian, Lenawee Co., Michigan (C. Goodrich).
Lake Huron, Port Huron, St. Clair Co., Michigan (N. M. Grier).
Bessey Creek, Cheboygan Co., Michigan (H. B. Baker).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).

Distribution and Ecology (See fig. 16): *Type locality*, Buck Creek, Ohio (Lea).[123]

In Pennsylvania this form is restricted to Lake Erie, and is found there in great numbers, chiefly in certain beach-pools on Presque Isle. It lives there in

[123] Location unknown. Possibly near Cincinnati?

the characteristic fine sand of the peninsula, sometimes mixed with more or less mud.

This variety has been reported from other localities in Lake Erie, for instance at Buffalo (Marshall, 1895), and also from Lake Michigan in Michigan (Walker, 1898) and Illinois (Baker, 1898*a*; Walker, 1913, p. 22). Records from other larger or smaller lakes and from canals are abundant from eastern Canada, Lower St. Lawrence region (according to Bell, 1859), New York (crossing over by way of Erie Canal to the Hudson at Albany) (Marshall, 1895), northern Ohio (Sterki, 1907*a*), Michigan (Walker, and Baker, 1914), as far north as Schoolcraft and Alger Cos., near Lake Superior (Winslow, 1917). But it also has been reported from creeks and rivers, and its type-locality is a creek in Ohio. It is found in New York, Ohio, Indiana (Call, 1896*a*, and 1900), and in Illinois (Baker, 1898*a*, and 1906) in streams running to the lakes as well as to the Ohio. But on the whole its range is more northeastern, and centers mainly in the drainage of the Great Lakes and the St. Lawrence. Southward and westward it does not go beyond Ohio and Indiana, nor beyond the northeastern corner of Illinois.

Genus Alasmidonta Say (1818).

Ortmann, 1912, p. 294; Simpson, 1914, p. 492; Ortmann, 1914, p. 44.

Type *Monodonta undulata* Say.

This genus has been divided into subgenera by Simpson, but they have been somewhat modified by the present writer. Three subgenera are found in Pennsylvania.

Key to the Subgenera.

a_1. Hinge complete, with pseudocardinals and laterals, but the latter reversed, two in right, one in left valve. Beak-sculpture moderately heavy.....Subgenus *Prolasmidonta*.

a_2. Hinge incomplete, laterals obliterated, pseudocardinals present. Beak-sculpture very heavy.

b_1. Pseudocardinals well-developed, stumpy. Posterior ridge weak, posterior slope smooth (rarely with traces of wrinkles). Rays not broken up into spots.....Subgenus *Alasmidonta*.

b_2. Pseudocardinals weak, compressed. Posterior ridge distinct, posterior slope more or less corrugated. Rays generally broken up into spots.....Subgenus *Decurambis*.

Subgenus Prolasmidonta Ortmann (1914).

Ortmann, 1914, p. 44.

Type *Unio heterodon* Lea.

There is only one species in this subgenus.

ALASMIDONTA (PROLASMIDONTA) HETERODON (Lea) (1830).

Alasmidonta heterodon (LEA) SIMPSON, 1914, p. 499; *Alasmidonta* (*Prolasmidonta*) *heterodon* (LEA) ORTMANN, 1914, p. 44.

Plate XII, figs. 1, 2.

Records from Pennsylvania:

Lea, 1830 (Schuylkill River and Darby Creek, the latter chiefly in Delaware Co.)
Conrad, 1838 (Schuylkill River).
Gabb, 1861 (Schuylkill River, below Fairmont Dam, Philadelphia.)
Hartman & Michener, 1874 (Schuylkill River, Chester Co.)
Marshall, 1895 (Philadelphia).
Schick, 1895 (Schuylkill Canal at Philadelphia and Manayunk; Neshaminy Creek, Bucks Co.)
Ortmann, 1909*b*, p. 207.

Characters of the shell: Shell small and rather thin. Outline subrhomboidal or subtrapezoidal to subovate, and more or less elongate, rounded anteriorly, subangular behind, with an upper posterior angle (which may be obsolete), and a more distinct and produced lower posterior angle. Lower margin gently curved (chiefly in the male), or straight and even slightly concave (chiefly in the female). Beaks somewhat inflated, but not very prominent, anterior to the middle of the shell, but not very near the anterior end. Beak-sculpture consisting of three or four (rarely traces of a fifth) bars, the first two concentric and simple, the following ones with a distinct angle upon the posterior ridge, in front of which is a more or less distinct, shallow sinus. The bars are moderately heavy and blunt, and the sinus never assumes the shape of a re-entering angle, sometimes it is barely indicated. Thus the beak-sculpture cannot be called double-looped. Upon the posterior slope there are one or two fine radiating lines, indicating as many additional bars, which are obliterated on the disk.

Shell more or less swollen and inflated, chiefly in the region of the posterior ridge, and in the female; the sides are rather flat. Posterior ridge quite distinct, generally more so in the female than in the male, but also in the latter this ridge is distinct, although rounded. In the female, it becomes almost angular. The posterior slope is somewhat compressed in the male, while in the female it appears sometimes almost truncated.

Epidermis greenish olive to brownish. Sometimes obscure (rarely more distinct), simple and straight rays are present, but in other cases, rays are invisible, and the color of the whole surface is uniform. Often there are indistinct concentric bands of lighter and darker green. Growth-rests indistinct.

Hinge complete, with pseudocardinals and laterals, but teeth rather feeble. Pseudocardinals two in each valve, compressed and crenulated, often the anterior

in the right valve, and sometimes the posterior in the left valve rudimentary. In addition, there is an interdental tooth in the left valve, which may be well-developed and isolated, or may be more or less connected with the posterior pseudocardinal, or may be even rudimentary. There is great variation in this respect. Laterals rather thin and short; characteristically there are two laterals in the right, and one in the left valve (just the reverse of the normal condition in the Naiades), but there is considerable variation in the laterals. The upper one is generally not so sharp as the lower one, and the former may be more or less rudimentary, sometimes only for a part of its length. Beak-cavities moderately developed, not deep. Dorsal muscle-scars distinct, in the beak-cavity. Adductor muscle-scars moderately deep anteriorly, faint posteriorly.

Nacre bluish or silvery white, iridescent, and often inclining toward cream-color or yellowish in the beak-cavity; sometimes with greenish or grayish discoloration.

Shells of males and females distinguishable. The male as a rule has a more compressed, and more ovate and elongate shell, with the lower margin gently and uniformly curved, the posterior ridge less sharp, and the posterior slope not truncate; while in the female the shell is more swollen in the region of the posterior ridge and just in front of it; has a more distinct posterior ridge, which renders the posterior slope more truncate, and makes the whole outline of the shell shorter and more trapezoidal. Furthermore in the female the lower posterior angle is more produced downward, so that the lower margin of the shell becomes rather straight, in some cases even concave. In young specimens the sexual differences of the shell are not seen, and prevalently the young females in shape resemble males.

		L.	H.	D.
Size: 1.	Kunkletown, Cat. No. 61.4652 (♂)	48 mm.	27 mm.	19 mm.
2.	Manayunk, Cat. No. 61.4250 (♂)	42 "	23 "	14 "
3.	do. Cat. No. 61.4249 (♀ gravid)	40 "	23 "	16 "
4.	do. Cat. No. 61.4250 (♂)	38 "	21 "	14 "
5.	do. " " do. (♀ gravid)	38 "	21 "	15 "
6.	do. Cat. No. 61.4249 (♀ gravid)	35 "	20 "	14 "

Soft parts (See Ortmann, 1912, p. 295). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 8).

Breeding season: Conner (1909, p. 112) found this species gravid in February, and I found gravid females with glochidia on April 24, 1909.

Remarks: A small species, easily overlooked, with no striking external features. However, the general shape, chiefly the distinct posterior ridge, give it the un-

mistakable aspect of an *Alasmidonta*. If attention is paid to the hinge, there can be no mistaking this shell, for the teeth are unique, at least among Pennsylvanian shells.

There are no species related to this in western Pennsylvania, and this species has altogether a rather isolated position in the system (See Ortmann, 1913*a*, pp. 324, 361).

Localities represented in the Carnegie Museum:

Delaware River, Shawnee, Monroe Co., Pennsylvania.
Princess Creek, Kunkletown, Monroe Co., Pennsylvania.
Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania.
Marsh Run, three miles S. E. of Remington, Fauquier Co., Virginia (Rappahannock-drainage).
Mountain Run, Culpeper, Culpeper Co., Virginia (Rappahannock-drainage).

Locality represented in the Philadelphia Academy of Natural Sciences:

Big Neshaminy Creek, " Edderton," [124] Bucks Co., Pennsylvania (H. W. Fowler).

Distribution and Ecology (See fig. 17): *Type locality*, Schuylkill River, Pennsylvania (Lea).

In Pennsylvania this species is decidedly rare. I have found it in large numbers only in the Schuylkill Canal; at other localities only a few were obtained. It is

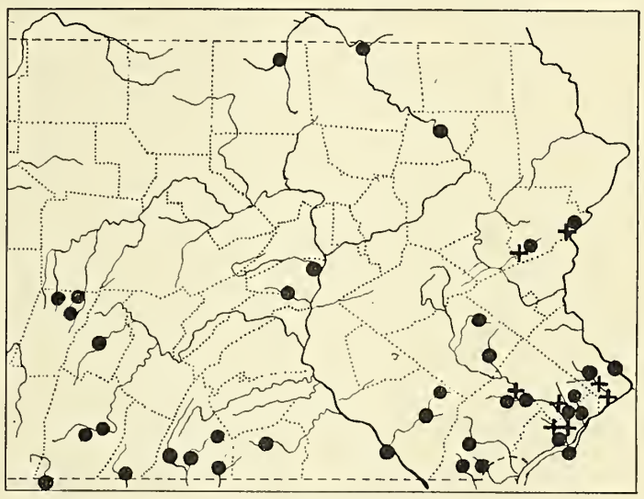


Fig. 17.

\+ *Alasmidonta heterodon.*
● *Alasmidonta undulata.*

known from a number of localities in the Delaware-drainage in the vicinity of Philadelphia, and chiefly from streams on the Piedmont Plateau. But in the

[124] Probably = Eddington.

Delaware at Shawnee and at Kunkletown (in a stream tributary to the Lehigh River) I found it to the northwest of the Blue Mountain (Kittatinny Mountain).

No trace of it has ever been seen in the Susquehanna and Potomac drainages, but it is positively present in the Rappahannock-drainage in Virginia, and here again it is on the Piedmont Plateau. (Ortmann, 1913*a*, p. 319.)

According to Simpson (1900), it goes from "northern New England to Virginia," but even in New England and New York locality-records are quite scarce. It is known from the Connecticut River, Hartland, Windsor Co., Vermont (Marshall, 1895), from Massachusetts (Marshall, but not mentioned by Gould-Binney, 1870), and in Connecticut from the Housatonic River (Linsley, 1845) and Mixville (Cheshire) New Haven Co. (Marshall) (see also Johnson, 1915). In New York, it is known from the southeastern portion (Marshall, without exact localities). Otherwise definite records are missing, but the extension of its range southward to Virginia, as given by Simpson, has been confirmed by the present writer with regard to the Rappahannock River.

For the present it may be said that the chief feature of the distribution of this species is its erratic character. As far as I can now see, it seems to be most likely a species of the Piedmont Plateau. Its apparent absence in the Susquehanna and Potomac drainages may be due to the incomplete investigation of the Piedmont tributaries of these rivers.

At Kunkletown and in the Rappahannock-drainage, I found this species in very small streams ("runs"), in strongly flowing water, and in rather coarse gravel, but at each locality only few specimens. In the Delaware at Shawnee it was (one specimen) in a small branch of the river in sand and moderate current. In the only case where I collected large numbers (about fifty), I found it under very different conditions, and that was in the canal at Manayunk at a time when the water had been drained off and only a few inches of water were left in the middle. Here the bottom consisted of larger and smaller stones, the interstices filled with sandy mud. This, however, cannot be regarded as normal, and the ecological conditions of this species remain to be studied.

Subgenus Alasmidonta Simpson (1900).

Alasmidonta Simpson, 1914, p. 493, + *Bullella, ibid.*, p. 508; *Alasmidonta* Ortmann, 1914, p. 45.

Type *Monodonta undulata* Say.

Only one species in Pennsylvania belongs to this subgenus.

Alasmidonta (Alasmidonta) undulata (Say) (1817).[125]

Alasmidonta undulata (Say) Simpson, 1914, p. 494.

Plate XI, fig. 7.

Records from Pennsylvania:

Say, 1817 (Delaware River).

Gabb, 1861 (Delaware, Schuylkill, and Wissahickon, Philadelphia; headwaters of Frankford Creek, Montgomery Co.)

Bruckhart, 1869 (Lancaster Co.)

Hartman & Michener, 1874 (Chester Co.)

Harn, 1891 (western Pennsylvania).[126]

Schick, 1895 (Canal at Manayunk, Philadelphia Co.; Munckinipattus Creek, Glenolden, Delaware Co.; Neshaminy Creek, Bucks Co.)

Ortmann, 1909*b*, p. 207.

Characters of the shell: Shell rather small, and rather thick, chiefly in its anterior part. Outline subtriangular, subovate, or almost subelliptical; generally comparatively short and high, more or less narrowed and pointed behind. Lower margin more or less convex. Upper margin straight, forming or not forming an angle with the obliquely descending posterior margin. Beaks more or less inflated, and somewhat elevated above the hinge-line, situated more or less anteriorly. Beak-sculpture extremely heavy, but somewhat variable. There are specimens with much heavier sculpture than others. Sculpture consisting of four or five bars, which are angular and much elevated posteriorly, straight or very little sinuated in the middle, rounded and low anteriorly, running up to the beaks upon the posterior slope as fine, but distinct, converging lines, and, in addition, there are several similar radiating lines behind them, as well as in front of the beaks. (See Marshall, 1890, fig. 11.) Upon the posterior slope there are sometimes irregular, oblique corrugations, but in most cases, they are absent.

Shell more or less swollen, lateral faces gently convex, with an oblique posterior ridge, which is rounded and often indistinct. Posterior slope somewhat compressed, rarely subtruncate.

Epidermis greenish, yellowish, reddish-brown, brown, or black, with more or less distinct dark green to blackish rays, which are broader or narrower, straight, uninterrupted. Old shells are often uniformly black-brown. Often the posterior slope is lighter than the rest of the shell, with more distinct, sharper, and finer rays. Frequently there are lighter or darker concentric bands. Growth-rests rather indistinct.

[125] Not 1816.

[126] This species certainly is absent from the Ohio-drainage. Harn's specimens may have come from the headwaters of the West Branch of the Susquehanna (See Ortmann, 1909*b*, p. 180).

Hinge incomplete. Pseudocardinals present, stumpy, crenulated, generally one in right, two in left valve, of which the anterior may be rudimentary. Interdental tooth of left valve poorly developed, generally connected with the posterior pseudocardinal. Laterals practically absent. Beak-cavity moderately deep. Dorsal muscle-scars distinct, upon the hinge-plate. Adductor scars deeply impressed anteriorly, less so posteriorly. Nacre white, salmon, pink, or red, the red shades prevailing, very iridescent posteriorly.

Shell of male and female indistinguishable.

	L.	H.	D.
Size: 1. Kimberton Dam, Cat. No. 61.883	77 mm.	52 mm.	37 mm.
2. Tioga, Cat. No. 61.4242 (♀ gravid)	69 "	41 "	28 "
3. do. " " do. (♂)	56 "	34 "	23 "
4. Greencastle, Cat. No. 61.4247 (♀ gravid)	48 "	32 "	18 "
5. do. " " do. (♂)	42 "	27 "	16 "

Soft parts (See Ortmann, 1912, p. 296). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 9).

Breeding season: I have the following dates for gravid females: July 18, 1908; July 22, 1910; Aug. 10, 1910; Aug. 11, 1910; Aug. 12, 1908; Aug. 13, 1910; Aug. 19, 1909; Sept. 5, 1909; Sept. 6, 1909. Then in spring, April 24, 1909; April 26, 1909; May 6, 1912; May 10, 1912; May 11, 1912; June 7, 1912; June 12, 1912; June 14, 1910.

This is clearly a *bradytictic* form, with a rather short interim, in June and July.

Remarks: Quite a well characterized species, not to be confounded with any other Pennsylvanian form, and having no related forms in the interior drainage system. The most nearly allied species are found in the southern parts of the Atlantic watershed, South Carolina and Georgia. It is easily recognized by the shape of the shell, heavy beak-sculpture, by the color and markings of its epidermis, and, on the inside of the shell, by the peculiar character of the hinge, and the often beautifully red tints of the nacre.

It is a rather variable shell, and the chief variations have been alluded to above.

Pennsylvanian localities, represented in the Carnegie Museum:

Delaware-drainage:

Delaware River, Yardley, Bucks Co.; Shawnee, Monroe Co.

White Clay Creek, Avondale, Chester Co.

Schuylkill Canal, Manayunk, Philadelphia Co.

Kimberton Dam, Chester Co. (Hartman collection) (formed by French Creek, near Phoenixville, Chester Co.)

Princess Creek, Kunkletown, Monroe Co.

Susquehanna-drainage:

Susquehanna River, Selinsgrove, Snyder Co.
Muddycreek, Lancaster Co. (G. H. Clapp, donor) (drainage of Conestoga Creek).
Conewago Creek, Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co.
Frankstown Branch Juniata River, Hollidaysburg, Blair Co.
Raystown Branch Juniata River, Everett, Bedford Co.
Shobers Run, Bedford Springs, Bedford Co. (A. Koenig).
West Branch Mahantango Creek, Richfield, Juniata Co. (D. A. Atkinson).
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson).
Swartz Run, Ashville, Cambria Co.
Chest Creek, Patton, Cambria Co.
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.
Mill-race of Crooked Creek, Tioga, Tioga Co.

Potomac-drainage:

East Branch Little Antietam Creek, Waynesboro, Franklin Co.
Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

Pennsylvanian localities represented in the Philadelphia Academy of Natural Sciences:

Manatawny Creek, Earlville, Berks Co. (H. A. Pilsbry).
Sacony Creek, Kutztown, Berks Co. (H. K. Deisher).
Schuylkill River, Phoenixville, Chester Co. (C. M. Wheatley).
"Valley Creek,"[127] southwest of Coatesville, Chester Co. (C. H. Conner).
"Big Elk Creek, Westgrove,"[128] Chester Co. (C. H. Conner).
Lancaster, Lancaster Co. (J. B. Eshleman).
Pequea Creek, Paradise, Lancaster Co. (W. Stone).
Susquehanna River, York Furnace, York Co. (W. Stone).

Other localities, represented in the Carnegie Museum:

Aroostook River, Caribou, Aroostook Co., Maine (O. O. Nylander).
Fish River, Eagle Lake, Aroostook Co., Maine (O. O. Nylander).
Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner).
Potomac River, Hancock, Washington Co., Maryland.
Wills Creek, Ellerslie, Allegany Co., Maryland.
South Branch Potomac River, Romney, Hampshire Co., West Virginia.
Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
North Fork Shenandoah River, Broadway, Rockingham Co., Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.

[127] Probably Sucker Run, tributary to West Branch Brandywine Creek.

[128] Not exact. The Middle Branch of White Clay Creek is at Westgrove and Big Elk Creek is about four or five miles farther West, at Lincoln University.

South River, Waynesboro, Augusta Co., Virginia.
Rappahannock River and Marsh Run, Remington, Fauquier Co., Virginia.
North River, Buena Vista and Lexington, Rockbridge Co., Virginia.
Calf Pasture River, Goshen, Rockbridge Co., Virginia.

Distribution and Ecology in Pennsylvania (See fig. 17): A common species in the Atlantic-drainage in Pennsylvania; but it is quite evident that it avoids the larger rivers, and prefers the smaller streams, where it becomes locally very abundant, going far up towards the headwaters, as is best seen in the upper Juniata and the tributaries of the West Branch of the Susquehanna in Cambria Co. Here it closely approaches the divide, but in no instance has it been found west of the divide.

It does not seem to favor riffles and very rough water, but is found chiefly in more quiet parts, but with some current, for instance, above riffles, where a steady flow of water prevails. It does not like slackwater, but occasionally it is found in ponds and canals; and it has been reported from several lakes in New York. It also likes mill-races, if the current is not too rapid. It lives mostly in a mixture of coarser or finer gravel with sand and mud; but I have taken it also in eddies with slow current embedded in the mud deposited between larger stones.

General distribution: Type locality, Delaware River, near Philadelphia (Say).

According to Simpson (1900), this species extends from the "Lower St. Lawrence-drainage southward to North Carolina." Its presence in the lower St. Lawrence (below Lake Ontario) is well established (Bell, 1859; Whiteaves, 1863; Marshall, 1895). In New York state it is found in the St. Lawrence-drainage, as in Lake Champlain (De Kay, 1843), Seneca and Crooked Lakes (Dewey, 1856); and in Onondago Co. (Marshall). It is more abundant still in the drainage of the Mohawk and Hudson Rivers, and of the upper Susquehanna (Chenango, Canisteo, Conhocton, and Tioga Rivers) (See De Kay, 1843; Lewis, 1860; Marshall, 1895).

It has been reported from Maine (Lermond, 1909; Nylander, 1914), from Keene, Cheshire Co., New Hampshire (Walker & Coolidge, 1908), and is rather common in Vermont (Adams, 1842), Massachusetts (Gould-Binney, 1870), Rhode Island (Carpenter, 1890), Connecticut (Linsley, 1845; Perkins, 1869) (See also Johnson, 1915, p. 26).

South of Pennsylvania it has been previously recorded from Sideling Creek, Allegany Co., Maryland (Pilsbry, 1894), and from Raleigh, Wake Co., North Carolina (Marshall, 1895), but other exact localities are not known to me. However that it exists in the Potomac, Rappahannock, and upper James drainages is shown by the material collected by myself for the Carnegie Museum.

The exact southern boundary of this species in North Carolina is unknown. Although its metropolis seems to be in the northern parts of the Atlantic watershed, we have reason to believe, on account of its southern affinities, that it belongs to the southern element in the Atlantic fauna (Ortmann, 1913*a*, pp. 324 and 361).

Subgenus Decurambis Rafinesque (1831).

Rugifera Simpson, 1900, p. 670; 1914, p. 504; Ortmann, 1914, p. 46; *Decurambis* Frierson, 1914*a*, p. 7.

Type *Alasmodonta marginata* Say.

Two species and one variety belong here.

Key to the Forms of Decurambis.

a_1. Posterior slope strongly truncate. Beaks placed more centrally, anterior end of shell more produced.

b_1. Shell greenish, posterior slope slightly lighter than the rest, but generally with rays. *A.* (*D.*) *marginata.*

b_2. Shell with posterior slope contrasted with the rest, light or reddish brown, hardly with rays. Rest of the shell brownish or yellowish, with distinct green rays. *A.* (*D.*) *marginata susquehannæ.*

a_2. Posterior slope less strongly truncate. Beaks placed more anteriorly, and anterior end of shell shorter. . . . . *A.* (*D.*) *varicosa.*

Alasmidonta (Decurambis) marginata (Say) (1819).

A. truncata (B. H. Wright) Simpson, 1900, p. 671; *A. marginata* (Say) Fox, 1901, p. 47; *Alasmidonta marginata* (Say) Simpson, 1914, p. 504.

Plate XII, fig. 3.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.; Beaver River, Wampum, Lawrence Co.)
Ortmann, 1909*b*, p. 196.

Characters of the shell: Shell of medium size, moderately thick, but rather thin when young. Outline subtrapezoidal, rounded before and triangular behind. Lower margin gently convex, more or less straight, or even somewhat concave in the posterior part. Upper margin straight or gently convex, forming a more or less distinct angle with the obliquely descending posterior margin. Beaks large and inflated, somewhat elevated above the hinge-line, situated somewhat in front of the middle, but at a considerable (although variable) distance from the anterior end. Beak-sculpture heavy, consisting of three or four thick bars, the second and third being a little produced and angular upon the posterior ridge, and having a more or less distinct sinus in front of the angle. This sinus is quite variable, some-

times rather distinct, so as to render the bars almost double-looped, sometimes hardly indicated, so that the middle part of the bars is almost straight. The fourth bar, if present at all, is rudimentary, and only its middle part is distinct. Radiating lines upon the posterior slope indistinct or absent. But upon the posterior slope there is a system of fine, irregular, radial wrinkles or ridges, running toward the upper posterior margin. These wrinkles are rarely absent or obscure, but generally well-developed; they may be finer or coarser, and may extend over a larger or smaller portion of the posterior slope; generally they are less distinct toward the posterior end in old shells.

Shell inflated, greatest width at or immediately in front of the posterior ridge. Lateral faces gently convex, with a very distinct posterior ridge, which, although rounded, is well marked in consequence of the truncated character of the posterior slope. Very often the posterior ridge appears as if bounded by two ridges, including an elevated part of the shell between them: this is chiefly the case toward the posterior end of old shells. The posterior slope is somewhat compressed and elevated in the middle, but in its general shape it presents a truncate, in some cases almost flat appearance.

Epidermis yellowish, greenish, or brownish, blackish in old shells, generally with very distinct greenish or blackish rays. Rays narrow or wide, straight, in most cases more or less broken up into (or overlaid by) darker spots. The spots are best developed towards the beaks, but often they are distinct all over the shell, and very rarely entirely wanting. Generally, the posterior slope is lighter in color than the rest of the shell, and has fewer and less distinct rays and spots. Often there are also lighter and darker concentric bands, marking, more or less, the growth-rests. In old shells, the color pattern becomes obscure, and the shell is more or less uniformly blackish.

Hinge incomplete. Pseudocardinals rather thin, but distinct, depressed-triangular (not stumpy), one in each valve, and the left valve has, in addition, a more or less well-developed interdental tooth, which may be separated from the pseudocardinal, or more or less united with it. More rarely it is rudimentary. Lateral teeth absent. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity upon the hinge-plate. Adductor-scars distinct and rather deeply impressed anteriorly, less so posteriorly.

Nacre bluish white, sometimes in places greenish or grayish, discolored, iridescent posteriorly, rarely with very pale salmon tints, never distinctly pinkish or reddish.

Shell of the female hardly distinguishable from that of the male. Some

shells are more inflated over the posterior ridge than others, and when this swelling reaches considerable proportions, we may be assured that we have to deal with a female. But not all females have this inflation, and often males are more inflated than females of the same size.

		L.	H.	D.	Distance of beaks from anterior end.	Pr.ct. of length.
Size: 1.	Shenango, Cat. No. 61.4270 (♂)	96 mm.	56 mm.	35 mm.	34	.35
2.	do. " " do. (♀ gravid)	92 "	53 "	40 "	29	.32
3.	Rose Point, Cat. No. 61.3139 (♂)	81 "	42 "	38 "	26	.32
4.	do. " " do. (♀ gravid)	73 "	39 "	27 "	22	.30
5.	do. " " do. (♂)	68 "	39 "	28 "	23	.34
6.	do. " " do. (♀ gravid)	63 "	36 "	26 "	21	.33

From the above table it is seen that the females are not always more swollen than the males. The location of the beaks is at about one-third of the length of the shell from the anterior end.

Soft parts (See Ortmann, 1812, p. 297). *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 27) and Surber (1912, Pl. 3, fig. 42). Surber's measurements are: 0.35 × 0.38, while mine are: 0.33 × 0.36 mm.

Breeding season: My records for breeding females cover the time from July 19 (eggs) till October 23. The earliest date for glochidia is September 2. It is to

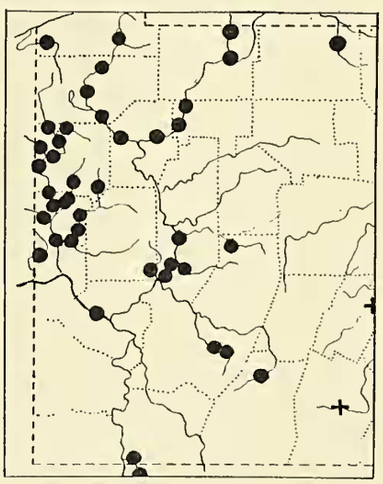


FIG. 18.

● *Alasmidonta marginata.*
\+ *A. marginata susquehannæ.*

be regretted that no dates are at hand for the spring months, but the species is undoubtedly bradytictic.

Remarks: This species is easily recognized and distinguished from others of the genus by the general shape, sculpture of the posterior slope, color of the epidermis, and by the hinge-teeth. There is no anodontine shell, except *Alasmidonta varicosa*, which could be confounded with it, but it bears an external and superficial resemblance in shape and color to a lampsiline shell, *Truncilla triquetra* Rafinesque. The latter, however, is much smaller and has a different hinge.

The typical form of *A. marginata* is a western shell. It is rather variable in shape. Its chief characters are its size, strongly truncate posterior end, and, in consequence of this, the more median position of the beaks, with the anterior end of the shell more developed. In this it is distinguished from its eastern representative, *A. varicosa*. But there are shells found in western Pennsylvania, chiefly in the mountain-streams, in which the truncation of the posterior end is not so pronounced. The existence of a peculiar race in the Susquehanna-drainage will be discussed below (See under var. *susquehannæ*).

Specimens from Conneaut Creek (drainage of Lake Erie) do not differ from the typical *A. marginata*.

Pennsylvanian localities represented in the Carnegie Museum:

Ohio- and Beaver-drainages:

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White & H. H. Smith).
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith).
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Wolf Creek, Grove City, Mercer Co.
Mahoning River, Mahoningtown, Lawrence Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.

Allegheny-drainage:

Allegheny River, Godfrey, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta, and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co. (Dennis Dally).
Buffalo Creek, Harbison, Butler Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Quemahoning Creek, Stanton's Mill, Somerset Co.
Crooked Creek, Rosston, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek Russell, Warren Co.

Monongahela-drainage:

Cheat River, Cheat-Haven, Fayette Co.

Lake Erie-drainage:

Conneaut Creek, West Springfield, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Conestogo River, Conestogo, Waterloo Co., Ontario, Canada (Miss Maria Jentsch).[129]

Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).

Maumee River, Waterville, Lucas Co., and Defiance, Defiance Co., Ohio (C. Goodrich); Fort Wayne, Allen Co., Indiana (C. Goodrich).

Ohio-drainage:

Tuscarawas River, Ohio (Holland collection).

Cheat River, Jaco and Mount Chateau, Monogalia Co., West Virginia.

West Fork River, Lynch Mines, Harrison Co.; Weston, Lewis Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.

Elk River, Shelton, Clay Co.; Gassaway, Braxton Co., West Virginia.

Greenbrier River, Ronceverte, Greenbrier Co., West Virginia.

Reed Creek, Wytheville, Wythe Co., Virginia.

Tennessee-drainage:

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).

Elk River, Fayetteville, Lincoln Co., Tennessee (H. H. Smith).

Flint River, Gurley, Madison Co., Alabama (G. H. Clapp, donor).

Paint Rock River, Paint Rock and Trenton, Jackson Co., Alabama (H. H. Smith).

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.

Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.

Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.

Clinch River, Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russel Co., Virginia; Richland, Tazewell Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

West of Mississippi:

Gasconade River, Gasconade, Gasconade Co., Missouri (W. I. Utterback).

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

[129] Grand River-drainage, to Lake Erie. The specimen at hand is normal.

Distribution and Ecology in Pennsylvania (See fig. 18): This species is rather frequent in the Ohio-drainage in western Pennsylvania, but decidedly avoids the larger rivers, and is more or less absent (probably extinct) in the Monongahela-drainage. Rhoads mentions it from the Ohio at Coraopolis, below Pittsburgh, but I never found it in the Ohio proper, nor in the Allegheny below Armstrong Co. In the Ohio between Pennsylvania and Cincinnati it is also missing. In the Monongahela-drainage it has been found only in Cheat River, but it turns up again in the upper Monongahela system (Cheat and West Fork Rivers) in West Virginia.

In the Beaver-drainage, this species is abundant, except in the extreme headwaters. From Armstrong County upwards it is found regularly in almost all streams tributary to the Allegheny, and goes far up into the upper Loyalhanna in Westmoreland Co., the Quemahoning in Somerset Co., the Little Mahoning in Indiana Co., and the uppermost Allegheny in McKean Co.

A. marginata is most decidedly a species of the riffles, being found there in finer or coarse, but firmly packed gravel, in swift currents. It is one of the species, which in the Conemaugh-drainage enter the valleys between Chestnut and Laurel Ridges and the Allegheny Front.

It occurs also in Conneaut Creek of the Lake Erie-drainage. Here it is rather abundant, and does not differ at all from the common form of western Pennsylvania. It should be noted that it never has been found on the Pennsylvanian shores of Lake Erie, although Sterki (1907*a*) reports a small, slight form, from the lake in Ohio, and Walker (1913, p. 22) reports *A. varicosa* from Lake Erie. I have never seen this lake-form.

Call (1900) remarks on the strongly developed foot of this species, which is, indeed, quite remarkable. When fully extended, the foot is firmly attached to the gravel in the river bed, and it requires quite an effort to dislodge the specimens.

General distribution: Type locality, Scioto River, Chillicothe, Ross Co., Ohio, Say. (See Fox, 1901.)

Simpson (1900) gives this species as from the "Upper Mississippi-drainage; Ohio, Cumberland, and Tennessee river systems; Michigan; Upper St. Lawrence-drainage." This is about right, but it should be noted that the species advances eastward into certain mountain-streams of the western slope of the Alleghenies, not only in the headwaters of the Tennessee in Tennessee and Virginia, but also in West Virginia and Pennsylvania, in the upper Kanawha system, and in the upper Conemaugh. In the Allegheny it also goes far up (to Olean, Cattaraugus Co., New York) (Marshall, 1895) and to McKean Co., Pennsylvania. It is known from several other localities in western New York, partly in the St. Lawrence,

partly in the Atlantic-drainage (Marshall and Baker, 1898*b*), but these records should be confirmed on account of the possibility, that this form may have been confounded with the eastern forms.[130] Thus the northeastern boundary of *A. marginata* is yet obscure. Northward this species has certainly crossed over into the lake-drainage, as is shown by a number of localities represented in the Carnegie Museum, and has been reported for Ohio (Dean, 1890; Sterki, 1907*a*), Indiana (Call, 1896*a* and 1900), and Illinois (Baker, 1898*a*, 1906). In Michigan, it has spread over the southern parts of the state, as far north as Roscommon Co. (Walker, 1898), and it is present in Ontario, north of Lake Erie (Carnegie Museum).

In the Mississippi this species goes up from Iowa (Pratt, 1876; Witter, 1878) to Minnesota (Grant, 1886; Holzinger, 1888).

West of the Mississippi, it seems to be much rarer. It is in the Wapsipinicon and Volga Rivers in Iowa (Geiser, 1910), and at Iowa City, Johnson Co., Iowa (Marshall), in Missouri (Utterback, 1916), but not in Kansas (Scammon, 1906). It is in the Ozark region of northern Arkansas (Carnegie Museum and Meek & Clark, 1912) going to the Ouachita River in central Arkansas (Wheeler, 1918). Thence southward it is missing.

ALASMIDONTA (DECURAMBIS) MARGINATA SUSQUEHANNÆ Ortmann.

Ortmann, 1913*b*, p. 315 (*et passim, sine descriptione*).

Plate XII, fig. 4.

Not previously recorded, except by Ortmann (1913*b*).

Characters of variety: Shell somewhat smaller than that of the normal form. Color of epidermis peculiar, brighter. Epidermis more or less brown (pale or reddish brown), with distinct green rays, which have a very strong tendency to break up into spots, which are very rarely absent. The posterior slope is always light in color, pale brown, reddish or yellowish, with hardly any green rays, so that it is in sharp contrast to the rest of the shell.

The nacre is whitish, but has quite frequently salmon or pinkish tints, in fact, delicate reddish tints are the rule in this variety, while the bluish-white of the western *marginata* is rarely present.

Finally the posterior truncation, although similar to that of many specimens of the western form, does not exhibit the extreme development, which is so often seen in the latter.

[130] Marshall, for instance, cites the Chemung and Tioga Rivers, belonging to the Susquehanna-drainage. The Carnegie Museum possesses specimens from the Tioughnioga River, Susquehanna-drainage, which surely are not typical *marginata*, but belong to the two eastern forms, var. *susquehannæ*, and the species *varicosa*.

Otherwise this form is like the western *marginata*, and differs markedly from the common eastern *A. varicosa*, with which it is sometimes found associated.

		L.	H.	D.	Distance of beaks from anterior end.	Pr.ct. of length.
Size: 1.	Carlisle, Cat. No. 61.4677 (♀ gravid)	79 mm.	41 mm.	30 mm.	23 mm.	.29
2.	do. " " do. (♂)	71 "	39 "	28 "	22 "	.30
3.	do. " " do. (♀ gravid)	69 "	36 "	29 "	23 "	.33
4.	Selinsgrove, Cat. No. 61.4679 (♀ gravid)	66 "	35 "	26 "	19 "	.29
5.	do. " " do. (♂)	61 "	36 "	28 "	20 "	.33
6.	do. " " do. (♂)	47 "	26 "	17 "	14.5 "	.31

Soft parts and *glochidia* identical with those of *A. marginata.*

Breeding season: The following records for gravid females are at hand: Aug. 13, 1908; Aug. 13, 1910; Aug. 14, 1910; Aug. 20, 1909; Aug. 20, 1909; Aug. 21, 1909; Sept. 8, 1909.

These dates indicate only the beginning of the breeding season early in August (eggs and glochidia found on first date!). Thus it is probably bradytictic.

Remarks: This is a new form, which has not been distinguished previously. It comes very near to the western *A. marginata* in shape, having a rather sharp posterior ridge and a more or less distinctly truncated posterior slope, and having the beaks nearer to the middle of the shell (at about one third of the length of the shell). It is practically a *marginata* in shape with a peculiar color, and is thus more closely allied to the western shell than to the eastern *A. varicosa*, and its presence on the Atlantic side is highly interesting.

Wherever this form is found associated with the eastern *varicosa*, the two may be distinguished at a glance, *varicosa* being smaller, with posterior ridge and posterior truncation less developed, and with generally a darker epidermis, without distinct spots, and the posterior slope not lighter, but rather darker than the rest of the shell.

Localities represented in the Carnegie Museum:

Susquehanna River, Duncannon, Perry Co., Pennsylvania.

Susquehanna River, Selinsgrove, Snyder Co., Pennsylvania.

Conodoguinet Creek, Carlisle, Cumberland Co., Pennsylvania.

Juniata River, Juniata Bridge, Perry Co., Pennsylvania.

Frankstown Branch Juniata River, Huntingdon and Alexandria, Huntingdon Co., Pennsylvania. (D. A. Atkinson).

Raystown Branch Juniata River, Ardenheim, Huntingdon Co.; and Mount Dallas, Bedford Co., Pennsylvania.

Penns Creek, Selinsgrove, Snyder Co., Pennsylvania.

North Branch Susquehanna River, Tunkhannock, Wyoming Co., Pennsylvania.

Chemung River, South Waverly, Bradford Co., Pennsylvania.

Tioughnioga River, Cortland, Cortland Co., New York (H. H. Smith) (drainage of upper North Branch Susquehanna).

Localities represented in the Philadelphia Academy of Natural Sciences:

Juniata River, Tuscarora, Juniata Co. (S. N. Rhoads); Newton-Hamilton, Mifflin Co. (H. T. Mather, Jr.); Mount Union, Huntingdon Co., Pennsylvania (S. N. Rhoads).

Distribution and Ecology (See figs. 18 & 19): *Type locality,* Susquehanna River, Selinsgrove, Snyder Co., Pennsylvania. *Type set:* Carnegie Museum Cat. No. 61.4679.

The above localities are all that are known, and they are restricted to the Susquehanna-drainage in Pennsylvania and New York. The form goes up the North Branch and its tributaries, reaching at least to Cortland, New York, and down the Susquehanna as far as the vicinity of Harrisburg (Duncannon). In addition, it is found in Conodoguinet Creek and the Juniata River. In the latter it ascends rather far (Mt. Dallas, Bedford Co.).

It should be noted, that it has not yet been found in the West Branch of the Susquehanna; the few individuals at hand from the West Branch-drainage are

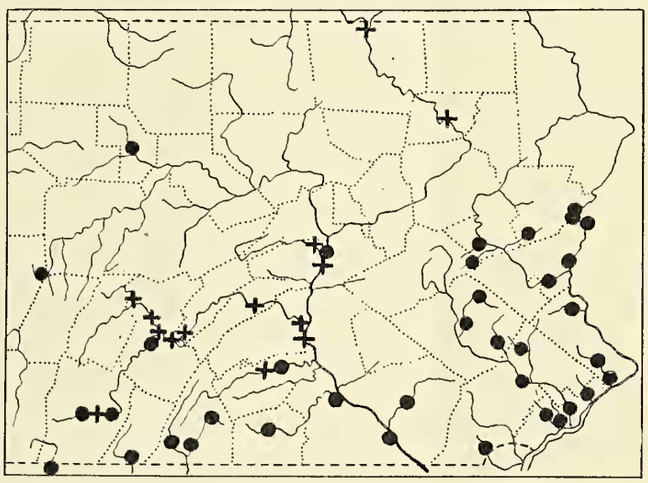


Fig. 19.

\+ *Alasmidonta marginata susquehannæ.*

• *Alasmidonta varicosa.*

all *A. varicosa.* However, this section of the Susquehanna system is poorly known, and most of it is badly polluted by mine-water and refuse from tanneries. Below Harrisburg, in the part of the Susquehanna which traverses the Piedmont Plateau, and in its tributaries in that region, this form has not been observed.

The ecological habits of this variety are identical with those of the western

marginata. It frequents riffles, and this renders it the more conspicuous, since there are few species on the Atlantic side which *prefer* this habitat.

According to our present knowledge, *A. marginata susquehannæ* is most abundant in the Juniata River, and those parts of the Susquehanna system, which are within the Allegheny Mountains. There is no trace of it in the Delaware or Potomac drainages.

The peculiar features of the distribution suggest the idea, that this form came from the West by crossing the Alleghenian divide. This has been discussed elsewhere (Ortmann, 1913*a*, pp. 370 *et seq*).

Alasmidonta (Decurambis) varicosa (Lamarck) (1819).

Alasmidonta marginata Simpson, 1900, p. 670; *Alasmidonta varicosa* (Lamarck) Pilsbry, 1901, p. 17; *Alasmidonta varicosa* (Lamarck) Simpson, 1914, p. 506.

Plate XII, fig. 5.

Records from Pennsylvania:

Lamarck, 1819 (Schuylkill River, Philadelphia).
Lea, Obs. II, 1838, p. 56 (Crum Creek, Delaware Co.)[131]
Bruckhart, 1869 (Lancaster Co.).
Hartman & Michener, 1874 (Chester Co.)
Marshall, 1895 (Philadelphia).
Schick, 1895 (Tohickon Creek, Bucks Co.; Neshaminy Creek, Bucks Co.; Munckinipattus Creek, Glenolden, Delaware Co.)
Ortmann, 1909*b*, p. 207.
Caffrey, 1911 (Delaware River, Northampton Co.)

Characters of the shell: The shell of this species differs from that of *A. marginata* by its smaller size, and by the outline, which is rather more subovate than subtrapezoidal, and slightly more elongate on the average. This difference of the outline is brought about by a different development of the posterior ridge and posterior slope. The posterior ridge is not so sharp, more broadly rounded, and often appears biangulate,[132] and the posterior slope is not so distinctly truncate. This renders the whole posterior section of the shell more elongated and rounded, and in consequence the anterior section is comparatively less developed, so that the beaks are situated more anteriorly, generally at a distance from the anterior end of considerably less than one-third of the length of the shell.

The color of the epidermis is much like that of *A. marginata*, with the darker

[131] By a mistake I have given this record (*Margaritana marginata*) under *Strophitus undulatus* (Ortmann, 1909*b*, p. 205).

[132] Indications of the biangulate character is sometimes found also in the western *A. marginata*.

green shades prevailing. There is sometimes a light (brownish) ground-color, with the rays not very strongly marked, but generally the dark green rays prevail, and often the whole shell becomes dark green or blackish. The rays do not possess a strong tendency to break up into spots, and are generally straight and simple, but of various widths. Distinct spots are rarely seen. The posterior slope is rarely lighter than the rest of the shell, and if so, the contrast is not well-marked; but, on the contrary, the posterior slope often appears slightly darker than the rest of the shell, which is due to a stronger development of dark green rays upon it. Nacre whitish or bluish-white, very often with salmon, pinkish, or purplish shades, which, however, are not very intense. Otherwise the shell is like that of *A. marginata.*

The female shells are slightly more swollen in the region of the posterior ridge. In old shells, this swelling is sometimes very distinct, and goes so far, that the lateral faces of the shell, in front of the ridge, appear flat or even concave, which concavity corresponds to a slight emargination of the lower margin.[133] However, sometimes males also show a slightly concave margin, and in many cases the sex cannot be positively recognized by the characters of the shell, since not all females have that swelling, and since the latter is sometimes also present in males.

	L.	H.	D.	Distance of beaks from anterior end.	Pr.ct. of length.
Size: 1. Ridley Creek, Cat. No. 61.4680 (♂)	70 mm.	38 mm.	29 mm.	18 mm.	.26
2. Kunkletown, Cat. No. 61.4671 (♀)	69 "	36 "	26 "	17 "	.25
3. do. " " do. (♂)	62 "	36 "	22 "	17 "	.27
4. Greencastle, Cat. No. 61.4675 (♂)	61 "	33 "	24 "	17.5 "	.29
5. Carlisle, Cat. No. 61.5873 (♀ gravid)	55 "	31 "	22 "	14 "	.25
6. Mt. Dallas, Cat. No. 61.4266 (♀ gravid)	45 "	26 "	18 "	12 "	.27
7. Mantz, Cat. No. 61.4253 (♂)	45 "	25 "	18 "	12 "	.27
8. do. " " do. (♀ gravid)	36 "	23 "	15 "	10 "	.28

There is another specimen from Ridley Creek, which is even larger than No. 1 (L. 75 mm.), but it is greatly deformed and freakish in shape, so that the dimensions are entirely abnormal.

The above figures show the more anterior location of the beaks, although the highest value corresponds to the lowest in *A. marginata.*

Soft parts and *Glochidia* identical with those of *A. marginata.*

Breeding season: Gravid females have been found: Aug. 9, 1910; Aug. 10, 1910; Aug. 11, 1910; Aug. 12, 1910; Aug. 13, 1908; Aug. 13, 1910; Aug. 14, 1910; Sept. 4, 1909; Sept. 5, 1909; Sept. 6, 1909; Sept. 8, 1909; and May 3, 1909.

[133] The concave lower margin is here decidedly more frequent than in *A. marginata.*

Breeding begins in August, when eggs are present; later, in September, glochidia are found. These are carried over the winter, and are still in the marsupium in May; discharge has been observed on May 3.

This species supplements somewhat the incomplete observations on *A. marginata*, and probably the breeding seasons of both species are about identical.

Remarks: This species has been frequently misunderstood, and confused with the western *A. marginata*. But Simpson (1900) (following Wright) recognized its specific distinctness, and I now hold the same opinion, although formerly (Ortmann, 1909*b*) I regarded it as a variety of *A. marginata*. But this was before I had realized that there is in the Susquehanna-drainage another form, which actually is more closely related to *A. marginata*.

A. varicosa is easily distinguished from *A. marginata* by the size and shape of the shell, and from the var. *marginata susquehannæ* it also differs in color. It is generally much smaller than either of them, and specimens over 60 or 65 mm. in length are quite scarce.

Although there is much variation in shape and color, this species hardly ever inclines toward the western form, and no intergrades are found. I possess only a single individual (dead shell) from White Clay Creek, Avondale, Chester Co., which has a sharper posterior ridge, and a lighter posterior slope, thus inclining toward the var. *susquehannæ*, but it has the general outline of *varicosa*, and, like this, no spots. Being the only individual found at that locality, we cannot draw any conclusions from it.

In the Susquehanna-drainage, I repeatedly found this species associated with *A. marginata susquehannæ*, but had never any difficulty in separating them. That there are two distinguishable forms in this region, was evident to me when I collected them together for the first time (Ardenheim, Aug. 13, 1908), and further study has only confirmed this view, although for a time I followed the views of previous authors.

Localities in Pennsylvania, represented in the Carnegie Museum:

Delaware-drainage:

Delaware River, Shawnee, Monroe Co.; Northampton Co. (G. W. Caffrey coll., G. H. Clapp donor); Yardley, Bucks Co.

White Clay Creek, Avondale, Chester Co.

Ridley Creek, Delaware Co. (C. H. Conner).

Lehigh River, Bethlehem, Northampton Co. (Holland collection).

Princess Creek, Kunkletown, Monroe Co.

Lizard Creek, Mantz, Schuylkill Co.

Mahoning Creek, Lehighton, Carbon Co.

Susquehanna-drainage:

Susquehanna River, York Haven, York Co.; Selinsgrove, Snyder Co.
Conewago Creek, Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co
Raystown Branch Juniata River, Ardenheim, Huntingdon Co.; Everett and Mount Dallas, Bedford Co.; Bedford, Bedford Co. (A. Koenig).
Driftwood Branch, Sinnemahoning Creek, Driftwood, Cameron Co.
Cush Cushion Creek, Green Township, Indiana Co. (D. A. Atkinson).

Potomac-drainage:

Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

Localities represented in the Philadelphia Academy of Natural Sciences:

Delaware River, Delaware Water Gap, Monroe Co. (S. N. Rhoads), and Columbia, Warren Co., New Jersey (S. N. Rhoads).
Big Neshaminy Creek, Edderton,[134] Bucks Co. (H. W. Fowler).
Pennypack Creek, Holmesburg, Philadelphia Co. (H. W. Fowler).
Swamp Creek, Zieglerville, Montgomery Co. (Bayard Long).
Manatawny Creek, Earlville, Berks Co. (H. A. Pilsbry).
Maiden Creek, Berks Co.
Sacony Creek, Kutztown, Berks Co. (H. K. Deisher).
Lancaster, Lancaster Co. (J. B. Eshleman).
Susquehanna River, York Furnace, York Co. (W. Stone).

Other localities represented in the Carnegie Museum:

Stony Brook, Princeton, Mercer Co., New Jersey.
Tioughnioga River, Cortland, Cortland Co., New York (H. H. Smith).
Potomac River, Hancock, Washington Co., Maryland.
Wills Creek, Ellerslie, Allegany Co., Maryland.
South Branch Potomac River, Southbranch, Hampshire Co., West Virginia.
Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.
South River, Waynesboro, Augusta Co., Virginia. (Headwaters of South Fork of Shenandoah.)
Catawba River, Bridgewater, Burke Co., North Carolina.

Distribution and Ecology in Pennsylvania (See fig. 19): From the published records it is seen that this species belongs to the Atlantic-drainage in Pennsylvania, and that it is rather evenly distributed over it, with the possible exception of the larger rivers. Specimens found by myself in the Delaware and lower Susquehanna are only few. In the smaller streams this species is more abundant, and locally common. This agrees well with the conditions seen in the western *A. marginata*, and with this *A. varicosa* also agrees in that it is distinctly a shell which

[134] Probably Eddington.

prefers strong currents and gravelly bottoms, thus being most frequently found in and near riffles. In the mountains it goes far up into the headwaters, and the most western locality is in Indiana Co., in a tributary of the West Branch of the Susquehanna (Cush Cushion Creek).

General distribution. Type locality, Schuylkill River, Philadelphia (Lamarck).

According to Simpson (1900), this species extends over the Atlantic-drainage from the lower St. Lawrence to South Carolina.

As has been stated above, the mutual relations of *A. varicosa* and *marginata* in central and western New York are doubtful, and specimens from New York are generally recorded under the name of *marginata,* although it is beyond doubt, according to our material, that *varicosa* is found in the upper Susquehanna-drainage in New York, and, according to the figures of DeKay in other parts of the state also.

The species has been reported from Maine (Lermond, 1909), New Hampshire (Call), Massachusetts (Gould-Binney, 1870), Rhode Island (Carpenter, 1890), and Connecticut (Linsley, 1845) but Johnson (1915, p. 27) erroneously calls the New England form *A. marginata.* Southward from Pennsylvania, *A. varicosa* is known from Red Clay Creek, Christiania Township, Newcastle Co., Delaware (Rhoads, 1904), and from the Potomac-drainage, in addition to the localities represented in the Carnegie Museum, from Sideling Creek, Allegany Co., Maryland, the Potomac River, Cherry Run, Morgan Co., West Virginia (Pilsbry, 1894).

Farther South, exact localities are missing, but Simpson's statement, that it extends to South Carolina, is substantiated by specimens collected by myself in the upper Catawba River in North Carolina. Among the latter are individuals which fully agree with the Pennsylvanian form, but this set is extremely variable in shape and especially in color.

A. varicosa of the Atlantic slope is the representant of the western *A. marginata,* and in its distribution apparently falls in line with several other Atlantic species, constituting a northern stock in the fauna of the Atlantic slope. This has been discussed elsewhere (Ortmann, 1913*a*, p. 363 & 370).

Walker (1913, p. 22) reports this species from Lake Erie; this, however, requires renewed attention, since the form from Lake Erie may belong to *A. marginata* (see above). I have never seen the lake-form, and thus I am unable to judge.

Genus Strophitus Rafinesque (1820).

Ortmann, 1912, p. 299; Simpson, 1914, p. 344.

Type *Anodonta undulata* Say.

Two species of this genus are generally credited to Pennsylvania, but I have been able to find only one (*S. edentulus*), which is distributed all over the state both on the western and the eastern side of the mountains. The type-species possibly originally came from Pennsylvania, but being founded upon a very poor and immature specimen, has been largely misunderstood. Simpson (1900, p. 618; 1914, p. 345 & 349) admits the existence, on the Atlantic side, of "a small, thin form, . . . usually biangulate behind," but I have not been able to locate it.

Conner believes, that he has rediscovered the true *S. undulatus* of Say, and I have received from him specimens from the New Jersey side of the Delaware River (not far from the supposed type-locality of Say's specimen, on the Pennsylvania side of the river). However, I can see only a local race of the common *S. edentulus* in this, probably belonging to the tidewater region of the Delaware River, and connected by intergrades with the common form, wherever the latter goes into large and more quiet bodies of water. But since my material is entirely insufficient to solve the question, I shall mention here the two forms as *species*, thus avoiding the inconvenience of having to call the typical, common form by a varietal name (*S. undulatus edentulus*), and making the local race the main species (*S. undulatus*).

Strophitus undulatus (Say) (1817).[135]

Simpson, 1914, p. 349 (but synonymy largely incorrect).

Plate XII, fig. 6.

Records from Pennsylvania:

Say does not give a type-locality for his *Anodonta undulata*, but his specimen probably came from near Philadelphia.

Lea (Obs. II, 1838, p. 54, and Obs. X, 1863, p. 450) repeatedly reports *A. undulata* Say from the Schuylkill River, near Philadelphia, and distinguishes it from *A. edentula*. The mouth of the Schuylkill, on the Delaware is just opposite the locality where Conner obtained his specimens.

All other records for this species are either very doubtful, whether they belong to the true *undulatus*, or are positively referable to *S. edentulus*.

(See Ortmann, 1909*b*, pp. 194 & 205.)

Characters of the species: Like *S. edentulus* in every particular, except that the beaks are slightly more inflated, elevated, and incurved. In consequence of this the shell appears higher anteriorly, and more tapering and pointed posteriorly.

[135] Not 1816.

	L.	H.	D.
Size: 1. (♀)	53 mm.	33 mm.	23 mm.
2.	52 "	33 "	24 "

These are the two largest at hand.

Soft parts: I have seen only those of a sterile female, and find them identical with those of *S. edentulus*. *Glochidia* unknown.

Breeding season: Conner (1909, p. 112, as *Anodonta undulata*) found this form gravid in December and March, but not in April and May.

Remarks: For all the material I possess I am indebted to the kindness of Mr. C. H. Conner, who sent me eight specimens, all from the tide-waters of the Delaware River, near Newbold, Gloucester Co., New Jersey. These specimens show the differential characters given above. Mr. L. S. Frierson (*in litteris*) has called my attention to certain supposed differences in the hinge, but I am unable to see them. Moreover the shape of the shell is somewhat variable in the eight specimens at hand, and further I have specimens of the western *S. edentulus* (chiefly from quiet waters) which come very near to this form from the Delaware in the inflation of the beaks. Further I have certain large and old specimens of *S. edentulus*, where the inflation of the beaks is much greater than in any specimen from the Delaware. For instance a giant specimen from Cush Cushion Creek (abandoned reservoir) is very remarkable in this respect; but it was found among a large number of typical *edentulus* and cannot be anything else.

In the hinge there is the same variation as in *S. edentulus*. In some specimens vestiges of teeth are seen, in others they are almost entirely obliterated, and indicated only by slight thickenings and curves of the hinge-line. Mr. Frierson maintains that the tooth of the left valve (cardinal + interdental) is absent, and represented by an excavation. This does not hold good for all specimens before me, and, on the other hand, this is a condition, *very often* seen in *S. edentulus*.

I am very much inclined to think that this is only a local variety, or even only an ecological race, belonging to the tidewaters of the Delaware River, and localities with a similar environment. In the Delaware, just below Trenton, New Jersey (at Penns Manor, Bucks Co., Pennsylvania) I collected a specimen, which is rather small, and well agrees in outline with the specimens received from Mr. Conner, but the beaks are not inflated and elevated. Specimens from the Delaware River, Trenton, in the Philadelphia Academy, are typical *S. edentulus*. On the other hand, a specimen of *S. edentulus* from the Delaware-Raritan Canal, specimens from Conneaut Lake, Lake Erie, and Winona Lake, have the shells inflated more than usual, although the beaks are not so elevated as in the form from the lower Delaware, and thus the outline is more regularly elliptical, and

not ovate (higher anteriorly). Then again the ovate outline, with the anterior part of the shell high, and the posterior part more or less tapering, is also represented in typical *S. edentulus* with compressed shell.

The real *S. undulatus* therefore remains a disputed form.

Of course *S. undulatus*, as discussed here, is not fully identical with Simpson's *undulatus*, for Simpson included in this all small, thin, and generally distinctly biangulate shells (Simpson, 1900, p. 618, *footnote*). But these characters well fit *young* specimens of *S. edentulus*, while the specimens received from Conner are *not* biangulate behind, on account of the tapering posterior end.

Locality represented in the Carnegie Museum:

Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner).

Distribution (See fig. 21): Frierson has sent me for examination a specimen from Warwick Pond, Warwick, Rhode Island, and another one from Orange Co., Virginia, but I have not been able to satisfy myself that they belong here, as was supposed, and that they are a species distinct from *S. edentulus*. Johnson (1915) keeps *S. undulatus* apart from *S. edentulus*, and gives for the former, a number of localities in New England, but I have no means of deciding what he understood by this species. No other records are known positively referring to this form.

Strophitus edentulus (Say) (1829).

Strophitus edentulus (Say) Simpson, 1914, p. 345, and *Strophitus undulatus* Simpson (*pro parte*), *ibid.*, p. 349.

Plate XII, figs. 7, 8.

Records from Pennsylvania:

? Lea, Obs. X, 1863, p. 450 (Schuylkill River, Philadelphia).[136]

Bruckhart, 1869 (as *edentula*) (Lancaster Co.)

Hartman & Michener, 1874 (as *edentula*) (Brandywine Creek, Chester Co.)

Harn, 1891 (as *undulata*) (western Pennsylvania).

Schick, 1895 (as *undulata*) (Canal, 27th ward, Philadelphia).

Marshall, 1895 (as *edentula*) (Allegheny River, Warren Co.)

Rhoads, 1899 (as *edentula*) (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.)

Ortmann, 1909*b* (as *undulatus*), p. 194, 202, 207.

Characters of the shell: Shell of medium size, rather thin when young, moderately thick when old. Outline subelliptical to subovate, broadly rounded in front, more narrowly rounded behind, sometimes somewhat pointed or biangulate behind.

[136] Lea frequently refers to *A. undulata* as coming from the Schuylkill River. He distinguishes it from *A. edentula*, but we cannot tell which form he had in mind.

Lower margin convex or straight, sometimes slightly concave in the middle. Upper margin gently convex, forming a more or less distinct angle with the obliquely descending posterior margin. Beaks little prominent, situated in front of the middle. Beak-sculpture distinct, moderately heavy, consisting of about four concentric bars, placed obliquely with reference to the hinge line, rounded anteriorly, angular upon the posterior ridge. A few radiating lines anteriorly and posteriorly to the bars (See Marshall, 1890, fig. 12).

Shell generally gently convex or rather flat upon the sides, but occasionally more or less swollen or inflated. Posterior ridge indistinct and broadly rounded. Posterior slope somewhat compressed, and, when young, often elevated at the upper posterior angle.

Epidermis yellowish, greenish, brownish, or blackish, with more or less distinct greenish or blackish rays. Rays straight, narrow or wider, often quite obsolete. Posterior slope sometimes darker than the rest of the shell. Very old shells are mostly quite black all over. Concentric darker bands may be present.

Hinge much reduced. Lateral teeth entirely absent; pseudocardinals indicated only by slight swellings of the hinge-line; rarely can the single elements be made out. Generally, the hinge-line is only somewhat wavy under the beaks. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Anterior adductor-scars rather distinct, posterior ones less so. Nacre bluish white, toward the thick part of the shell pure white, or cream-color, and very often salmon-pinkish.

Male and female shells practically indistinguishable.

	L.	H.	D.
Size: 1. Cush Cushion Creek, Cat. No. 61.3627 (♂)	106 mm.	56 mm.	43 mm.
2. Grove City, Cat. No. 61.3278 (♀ gravid)	102 "	55 "	39 "
3. Tioga, Cat. No. 61.4154 (♀ gravid)	81 "	41 "	32 "
4. Milesburg, Cat. No. 61.4158 (♀ gravid)	74 "	42 "	27 "
5. Warren, Cat. No. 61.4164 (♂)	66 "	37 "	22 "
6. Darlington, Cat. No. 61.2945 (♂)	44 "	25 "	16 "

Soft parts: A poor figure was published by Lea (Obs. II, 1838, Pl. 15, fig. 47); a description was given by Ortmann, 1912, p. 299. *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 5), and Surber (1912, Pl. 1, fig. 3). Surber's measurements are: 0.350 × 0.285, while mine (*l. c.*, p. 300) are: 0.36 × 0.30 mm.

Breeding season: Records for gravid females are most complete. They cover the time from July 11 to November 4, and from April 17 to May 22. It is a typically *bradytictic* form, with the interim between the breeding seasons falling, in our region, in the end of May, June, and the beginning of July. Surber (1912) gives a shorter interval, only in July.

Remarks: Although very variable in outline and color, this species is easily recognized by the elliptical shape, and the rudimentary condition of the hinge. If gravid females are at hand, the marsupial structure unmistakably indicates the genus. Only *Anodontoides ferussacianus* might be confounded with this species, but the shell of the latter is generally thinner, and the nacre is more bluish white, with very little pure white, and further the beak-sculpture is much finer.

Specimens with well-defined rays have been called *pavonia* Lea. The type locality of this is Little Beaver Creek in Ohio. I possess many specimens from this creek in Pennsylvania, and among them are many which correspond to *pavonia*, but they are connected by all possible intergrades with the normal *S. edentulus*.

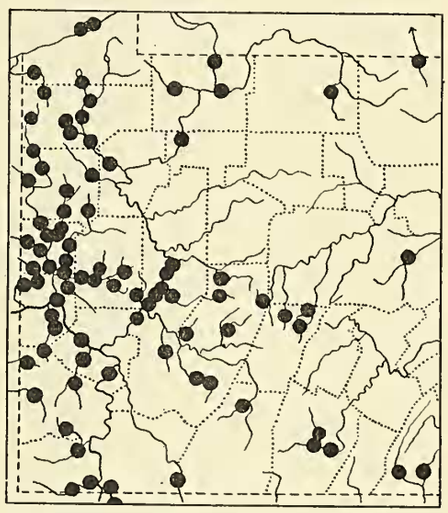


FIG. 20.

• *Strophitus edentulus* (western half of State of Pennsylvania).

Such brightly colored individuals may turn up anywhere, on the western as well as on the eastern side of the Alleghenies, and are always found associated with the normal form.[137]

There is little inclination to form local races, although under certain conditions and at certain localities the specimens look rather uniform. Thus in the mountain-streams on the western side of the mountains, there is a small, often more elongated race of *S. edentulus*, and the Allegheny River in general, does not produce very large, but rather heavy-shelled specimens. In the Beaver-drainage this species is much larger on the average. Strangely enough the largest specimens on record are from the Atlantic-drainage, in the headwaters of the West Branch of the

[137] Wilson & Clark (1912*a*, p. 48) believe that the better development of rays (in *pavonia*) is correlated with the clearness of the water, and I think that this is right.

Susquehanna (Cush Cushion Creek); but these came from an old, abandoned reservoir, with a muddy bottom and rich vegetation.

Specimens from Conneaut Creek, tributary to Lake Erie, do not differ from the normal type. However, in Lake Erie proper a peculiar form is found. I myself did not find many specimens, but I have received additional ones from C. Goodrich, and all these represent a dwarfed race (largest at hand: L. 51 mm., H. 28 mm., D. 20 mm.), of a rather regular, subelliptical and elongate outline. I do not, however, think it advisable to distinguish this race by a varietal name.

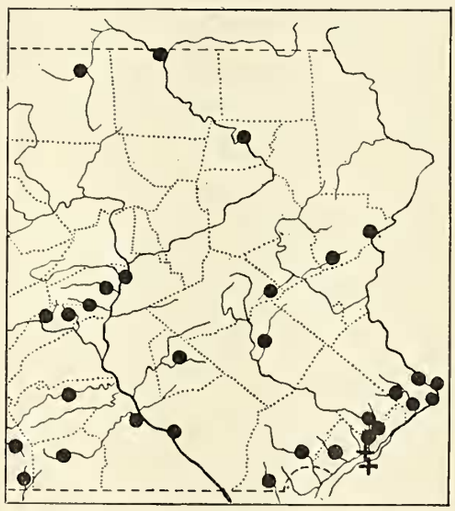


FIG. 21.

● *Strophitus edentulus* (eastern half).
+ *Strophitus undulatus.*

Localities in Pennsylvania, represented in the Carnegie Museum:

Small tributaries of the Ohio:

Buffalo Creek, Acheson, Washington Co.

Cross Creek, Avella, Washington Co.

Little Beaver Creek, Cannelton (H. H. Smith), Darlington, New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, Raccoon Township and New Sheffield, Beaver Co.; Bavington, Washington Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson & J. L. Graf).

Little Chartiers Creek, Morganza, Washington Co.

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith); Celia, Beaver Co.; Zelienople, Butler Co.; Harmony, Butler Co. (R. G. Pflaum).

Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.
Brush Creek, Celia, Beaver Co.
Little Connoquenessing Creek, Harmony, Butler Co.
Thorn Creek, McBride, Butler Co.
Bonnie Brook, East Butler, Butler Co.
Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.
Neshannock Creek, Eastbrook, and Volant, Lawrence Co.; Leesburg, Mercer Co.
Otter Creek, Mercer, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Shenango and Jamestown, Mercer Co.; Linnesville, Crawford Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.

Allegheny-drainage:

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Kelly, Mosgrove, and Templeton, Armstrong Co.; Hickory, Forest Co.; Warren, Warren Co.
Buffalo Creek, Harbison, Butler Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Beaver Run, Delmont, Westmoreland Co.
Blacklegs Creek, Saltsburg, Indiana Co.
Yellow Creek, Homer, Indiana Co.
Quemahoning Creek, Stanton's Mill, Somerset Co.
Crooked Creek, Rosston, Armstrong Co.; Creekside, Indiana Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co.
Conneauttee Creek, Edinboro, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

Monongahela-drainage:

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson).
Youghiogheny River, Confluence, Somerset Co.
Tenmile Creek, Clarksville, Greene Co.; Amity, Washington Co.
South Fork Tenmile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Lake Erie-drainage:

Conneaut Creek, West Springfield, Erie Co.; Springboro, Crawford Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

Genesee River-drainage:

Genesee River, Genesee, Potter Co.

Delaware-drainage:

Delaware River, Penns Manor and Yardley, Bucks Co.; Shawnee, Monroe Co.
Schuylkill River, Manayunk, Philadelphia Co.
Schuylkill Canal, Manayunk, Philadelphia Co.
Wissahickon Creek, Roxboro, Philadelphia Co.
Little Neshaminy Creek, Grenoble, Bucks Co.
Princess Creek, Kunkletown, Monroe Co.
Lizard Creek, Mantz, Schuylkill Co.

Susquehanna-drainage:

Susquehanna River, Selinsgrove, Snyder Co.
Conewago Creek, York Haven, York Co.; Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co.
Cocolamus Creek, Cocolamus, Juniata Co. (D. A. Atkinson).
Lost Creek, Mifflintown, Juniata Co. (D. A. Atkinson).
Raystown Branch Juniata River, Everett and Mount Dallas, Bedford Co.
Dunning Creek, Bedford, Bedford Co. (J. F. L. Raschen).
West Branch Mahantango Creek, Richfield, Juniata Co.
Middle Creek, Freeburg, Snyder Co. (D. A. Atkinson).
Bald Eagle Creek, Milesburg, Center Co.
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson).
Swartz Run, Ashville, Cambria Co.
Chest Creek, Patton, Cambria Co.
Cush Cushion Creek, Green Township, Indiana Co.
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.
Millrace of Crooked Creek, Tioga, Tioga Co.

Potomac-drainage:

East Branch Little Antietam Creek, Waynesboro, Franklin Co.
Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.

Pennsylvanian localities represented in the Philadelphia Academy of Natural Sciences:

Big Elk Creek, Westgrove, Chester Co. (C. H. Conner).[138]
Chester Creek, Delaware Co.
Maiden Creek, Berks Co.
Big Neshaminy Creek, " Edderton " (probably Eddington), Bucks Co. (H. W. Fowler).
Columbia, Lancaster Co. (J. B. Eshleman).
Little Swatara Creek, Jonestown, Lebanon Co. (C. H. Conner).

Additional locality in New Jersey:

Delaware River, Trenton, Mercer Co., New Jersey (H. Hamilton).

[138] Not exact, either creek or town given incorrectly.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Seneca Co., New York (Smith collection).
Conestogo River, Conestogo, Waterloo Co., Ontario, Canada (Miss Maria Jentsch).
Lake Erie, Port Dover, Norfolk Co., Ontario, Canada; Vermilion, Erie Co., Ohio; La Plaisance Bay Monroe Co., Michigan (C. Goodrich).
Creek at North Fairfield, Huron Co., Ohio (O. E. Jennings).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Swan Creek and Ten Mile Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Maumee River, Fort Wayne, Allen Co., Indiana (C. Goodrich).
Otter Creek, Monroe Co., Michigan (C. Goodrich).
Raisin River, Adrian and Tecumseh, Lenawee Co., Michigan (C. Goodrich).

Drainage of Red River of the North:

Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).

Ohio-drainage:

West Branch Nimishillen Creek, Canton, Stark Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Scioto River, Columbus, Franklin Co., Ohio (Smith collection).
Wabash River, St. Henry, Mercer Co., Ohio (C. Goodrich).
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).
Cheat River, Jaco and Mount Chateau, Monongalia Co., West Virginia.
Tygart River, Elkins, Randolph Co., West Virginia.
French Creek, Hampton, Upshur Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Licking River, Farmer, Rowan Co., Kentucky.

Cumberland- and Tennessee-drainages:

Cumberland River, Burnside, Pulaski Co., Kentucky (B. Walker, donor, soft parts only).
Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Tennessee River, Concord, Knox Co., Tennessee.
French Broad River, Boyd Creek, Sevier Co., Tennessee.
Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co., Tennessee.
South Fork Holston River, Pactolus and Bluff City, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Saltville, Smyth Co., Virginia.
Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; St. Paul, Wise Co., Cleveland, Russell Co., Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.
South Fork Powell River, Big Stone Gap, Wise Co., Virginia.

Mississippi River and westward:

Mississippi River, Museatine, Museatine Co., Iowa (Hartman eollection).
Meramee River, Meramee Highlands, St. Louis Co., Missouri (N. M. Grier).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Hollister, Taney Co., Missouri (W. I. Utterbaek); Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).
Blaek River, Blaek Roek, Lawrenee Co., Arkansas (H. E. Wheeler).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouaehita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Lawrenee, Douglas Co., Kansas (R. L. Moodie).
Fourteen Mile Creek, Fort Gibson, Muskogee Co., Oklahoma (F. B. Isely).

Atlantic-drainage:

Delaware-Raritan Canal, Princeton, Mereer Co., New Jersey.
Potomae River, Haneoek, Washington Co., Maryland.
South Branch Potomae River, Romney, Hampshire Co., West Virginia.
North Fork Shenandoah River, Broadway, Roekingham Co., Virginia.
South Fork Shenandoah River, Elkton, Roekingham Co., Virginia.
South River, Waynesboro, Augusta Co., Virginia.
Rappahannoek River, Remington, Fauquier Co., Virginia.
Rapidan River, Rapidan, Culpeper Co., Virginia.
Mountain Run, Culpeper, Culpeper Co., Virginia.
North River, Buena Vista and Lexington, Roekbridge Co., Virginia.
Calf Pasture River, Goshen, Roekbridge Co., Virginia.
Roanoke River, Salem, Roanoke Co., Virginia.
Mason Creek, Salem, Roanoke Co., Virginia.

Distribution and Ecology in Pennsylvania (See figs. 20 & 21): This is the only species of Naiad whose range covers the whole of the state of Pennsylvania, the divide of the Allegheny Mountains having no influence whatever upon it. The forms found on either side of the divide do not differ at all, and go far up into the headwaters, so that there is practical continuity of distribution across the divide. There is no doubt that this distribution is to be accounted for by an actual crossing over from the western to the eastern slope, and probably this has been effected by stream piracy. This has been discussed elsewhere (Ortmann, 1913*a*, pp. 367–369).

Strophitus edentulus also is extremely common all over the state, although it is distinctly averse to large rivers. Rhoads reports it from the Ohio below Pittsburgh, but I have never found it there. Above Pittsburgh it appears in the Allegheny, but is decidedly scarce in Allegheny and Armstrong Cos., and the specimens

are rather small on the average. Farther up, and in the tributaries, it becomes more and more abundant, and in all small creeks it is a common shell.

The fact is remarkable, that *S. edentulus* is the only Naiad present in the upper Youghiogheny. There is no other stream in Pennsylvania, which offers a parallel case, but such are found in several mountain streams in West Virginia. This has been discussed elsewhere (Ortmann, 1913*a*, pp. 303, 305, 308; 357, 367 *et seq.*).

Likewise on the Atlantic slope this species is scarce or missing in the large rivers. This is most evident in the lower Susquehanna. It is present in the Delaware near and above Trenton, New Jersey, but does not seem to be abundant. It may be that in the estuary of the Delaware *S. undulatus* takes its place.

We may therefore call *S. edentulus* a form characteristic of smaller streams. Baker (1898*a*, p. 68) says indeed that it is found in the larger lakes and rivers on muddy bottoms, while Scammon (1906, p. 323) reports it to prefer mud and quiet water, and to be most abundant in smaller streams (in Kansas). Its absence in the larger rivers in Pennsylvania may be connected with its aversion to rough bottom and strong currents. Even in the small streams it avoids riffles, but delights in quiet and protected nooks, pools, and eddies, where there is a moderate and rather uniform current, and a deposit of fine gravel, sand, or mud. It is often found in the *Dianthera*-patches.

On the other hand this species goes into canals and lakes. Altogether, it lives under a great variety of environmental conditions, and thus it is not astonishing that it is so widely distributed.

General distribution: Type locality, Wabash River (Say).

According to Simpson (1900) *S. edentulus* ranges over the "entire Mississippi-drainage; the St. Lawrence system and south in streams draining into the Atlantic to North Carolina; north in the British possessions to Lake Winnipeg; southwest to central Texas." (An Alabaman locality has also been recorded.)

This is substantially correct, and this is possibly the widest range occupied by any species of Naiad in North America. Its occurrence in Canada in the lower St. Lawrence-drainage, as well as in the west, is well-established (Whiteaves, 1863; Bell, 1859; Call, 1885; Dawson, 1875; Hanham, 1899; Christy, 1855; see also our records from Ontario and North Dakota). Its presence on the Atlantic slope from Maine (Lermond, 1909) southward is well known, and substantiated by our records as far South as the Roanoke system in Virginia. It is said to go to North Carolina (Simpson), but here the southern boundary is obscurely known.

The center of radiation is apparently located in the Mississippi system (See

Ortmann, 1913*a*, p. 367 *et seq.*). It is found everywhere in the drainage of the Ohio and in that of the upper Mississippi. There are sections, where records are scarce or missing, as for instance in Kentucky, and its absence in the upper Kanawha system in West Virginia and Virginia should be noted (See Ortmann, 1913, pp. 308 and 367). It seems to be rare in the Cumberland (Wilson & Clark, 1914), but in the upper Tennessee system in Tennessee and Virginia it is common.

In a westerly and southwesterly direction it goes across the Mississippi, and has been found as far west as eastern Nebraska (Tryon, 1868); in Kansas, as far as Saline Co., in the Kansas-drainage, and Reno County, in the southern drainage (Scammon, 1906). From Arkansas it has been reported by Call (1895) and Meek & Clark (1912), and it is represented from the Ozark streams, the Saline and Ouachita Rivers in the Carnegie Museum (previously reported from Ouachita by Vanatta, 1910, and Wheeler, 1918). It is also present in Oklahoma (Carnegie Museum). Frierson (1899) reports it from a tributary of Sabine River in De Soto Parish, Louisiana, and according to Simpson it goes to central Texas (Vaughan, 1893, does not mention it from northwestern Louisiana, and Singley, 1893, does not mention it from Texas).

Records from the southern Atlantic and Gulf states are lacking, though Simpson cites Tyner, Tuscaloosa Co., Alabama; and a number of allied forms, separated as species, are credited to Georgia, Alabama, and Mississippi. I cannot judge of these; but I may mention, that specimens from the Alabama-drainage in the Carnegie Museum, partly collected by H. H. Smith, partly by myself, seem to differ, and to represent possibly two other species: *S. connasaugaënsis* (Lea) (= *alabamensis* Lea = *gesneri* Lea), and *S. spillmani* (Lea). Both have the pseudocardinal teeth better developed than *S. edentulus*.

Subfamily LAMPSILINÆ (v. Ihering, 1901) Ortmann (1910).[139]

Ortmann, 1910, p. 118; 1911, p. 337; 1912, p. 300.

Key to the Genera of the Lampsilinæ.

a_1. Marsupium not kidney-shaped. Ovisacs subcylindrical or very slightly compressed. Placentæ generally very solid. Inner edge of mantle in front of branchial opening, not distinctly differentiated. Shell rounded, ovate, subelliptical, sometimes with sculpture upon the disk. Male and female shells practically alike.

b_1. Marsupium occupying the whole of the edge of the outer gill, folded. Placentæ club-shaped, short. Shell subelliptical, smooth. . . . . *Ellipsaria.*

b_2. Marsupium occupying only a part of the outer gill. Placentæ subcylindrical, elongated or very long. Shell more or less rounded, generally with tubercles.

[139] V. Ihering first coined this subfamily-name, but places some of the genera belonging here in his subfamily *Quadrulinæ*.

c_1. Placentæ moderately long, slightly curved. Marsupium just behind the middle of the gill. Outside of shell with a few large knobs. ..... *Obliquaria.*

c_2. Placentæ very long, spirally coiled up. Marsupium in, or slightly in front of, the middle of the gill. Outside of shell with numerous small tubercles. ..... *Cyprogenia.*

a_2. Marsupium kidney-shaped. Ovisacs lanceolate, dilated and compressed. Placentæ not very solid. Inner edge of mantle in front of branchial opening, more or less differentiated. Shell rounded, elliptical, or elongate, without sculpture on the disk.

b_1. Inner edge of mantle, in front of branchial opening, slightly lamellate and crenulated, but without papillæ or flaps. Male and female shell differing only slightly in shape, or hardly at all.

c_1. Shell rounded, ovate, or subelliptical. Glochidia of normal size and shape, subovate.

d_1. Shell rounded or short-ovate. Epidermis brownish, rarely greenish, with indistinct rays. ..... *Obovaria.*

d_2. Shell ovate or subelliptical, elongate. Epidermis greenish or yellowish, with more or less distinct rays. ..... *Actinonaias.*

c_2. Shell ovate, triangular, or subelliptical. Glochidia either of abnormal size or shape.

d_1. Shell subovate or subtriangular, with a strong posterior ridge.

e_1. Glochidia of normal shape (subovate), but of abnormally small size. Shell subovate or elongate. ..... *Amygdalonaias.*

e_2. Glochidia spatulate, with gaping margins, very large. Shell subtriangular. *Plagiola.*

d_2. Shell subovate or subelliptical, generally compressed and winged at the upper posterior part, without distinct posterior ridge.

e_1. Glochidia of normal shape, but of abnormally small size. Shell rather thin. *Paraptera.*

e_2. Glochidia celt-shaped, with two spines on each valve. Shell thicker. ..... *Proptera.*

b_2. Inner edge of mantle, in front of branchial opening, with papillæ or flaps. Male and female shell distinctly, and often greatly, different in shape.

c_1. Inner edge of mantle parallel with and close to the outer edge. Glochidia subovate or subelliptical.

d_1. Inner edge of mantle with papillæ.

e_1. Papillæ few, represented chiefly by one large caruncle. Shell very small. Beak-sculpture concentric. ..... *Toxolasma.*

e_2. Papillæ more numerous. Shell small, medium, or large. Beak-sculpture double-looped. ..... *Eurynia.*

d_2. Inner edge of mantle forming a ribbon-like flap, projecting at the anterior end. Shell large. ..... *Lampsilis.*

c_2. Inner edge of mantle, in front of branchial opening, more or less remote from outer edge in the female. Glochidia subcircular. Shell rather small, of peculiar and various shapes, chiefly in the female. ..... *Truncilla.*

Genus Ellipsaria Rafinesque (1820).

Ptychobrancus (Simpson) Ortmann, 1912, p. 305; Simpson, 1914, p. 332; *Ellipsaria* Frierson, 1914*a*, p. 7.

Type *Obliquaria fasciolaris* Rafinesque.

Only the type-species known from Pennsylvania.

Ellipsaria fasciolaris (Rafinesque) (1820).

Ptychobranchus phaseolus (Hildreth) Simpson, 1941, p. 333; *Ellipsaria fasciolaris* (Rafinesque) Frierson, 1914*a*, p. 7; *Ptychobranchus fasciolaris* (Rafinesque) Vanatta, 1915, p. 554.

Plate XIII, figs. 1, 2, 3.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, pp. 194 and 202.

Characters of the shell: Shell of medium size, but comparatively thick and heavy. Outline subelliptical, more or less elongated; when old, often humped (subtriangular), and drawn out at the lower posterior end. Upper and lower margins more or less convex, posterior end narrower than anterior, rounded or bluntly pointed. In old specimens the lower margin may be straight, and it sometimes becomes even concave in the middle. Beaks in front of the middle, very little elevated above the hinge-line. Beak-sculpture rudimentary, consisting of two or three faint ridges which are interrupted, and have thus a tendency to appear double-looped.

Valves moderately and rather evenly convex, slightly more flattened on the sides. Posterior ridge practically absent, or indicated only by a stronger convexity of the valves. No sculpture upon the surface.

Epidermis yellowish to light brown, rarely dark brown; generally ornamented with dark green rays, which are most distinct in young specimens. The rays are capillary and interrupted, but are generally grouped together in bundles, and very often fused together, so as to form more or less squarish, green spots. There is great variability in the size and the arrangement of these spots, and in very rare cases they are entirely missing. Old shells have the rays less distinct, and the epidermis becomes more or less uniformly brown. Concentric bands of color are absent, or the color is only slightly darker along the growth-lines.

Hinge well-developed. Pseudocardinals stumpy, heavy, but not much elevated. Laterals thick and heavy, club-shaped, thicker posteriorly. Interdentum narrow. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct and rather deep.

Nacre white, generally without any color, except in very young specimens, where there may be a faint pink blush.

Externally there are no sexual differences in the shell, except that the males

are slightly more compressed than the females. It is indeed often impossible to ascertain the sex by this character. Internally the female shell is marked by a wide, oblique groove, running from the beak-cavity toward the posterior end, which corresponds to the marsupium (Pl. XIII, fig. 2). The marsupial folds are also generally marked as depressions in this groove. These depressions are best marked in old specimens and are indistinct or absent in young ones.

	L.	H.	D.
Size: 1. Cannelton, Cat. No. 61.1166 (♀)	132 mm.	72 mm.	43 mm.
2. Harbor Bridge, Cat. No. 61.3601 (gravid ♀)	125 "	62 "	40 "
3. New Sheffield, Cat. No. 61.3275 (♂)	109 "	65 "	32 "
4. Shenango, Cat. No. 61.4134 (♂)	87 "	47 "	28 "
5. Rose Point, Cat. No. 61.3116 (♂)	73 "	42 "	22 "
6. Waterford, Cat. No. 61.4133 (♀ gravid)	66 "	36 "	21 "

Our largest specimens (Nos. 1 and 2) exceed the maximum size (110 mm.) recorded by Scammon (1906, p. 320).

Soft parts (See Ortmann, 1912, p. 306). They have been figured by Lea (Obs. VII, 1860, Pl. 29, fig. 101) and Lefevre & Curtis (1910, Pl. 1, fig. 1, and 1912, Pl. 6, fig. 1). *Glochidia:* Lea (Obs. VI, 1858, Pl. 5, fig. 12) poor; Ortmann (1911*b*, Pl. 89, fig. 14).

Breeding season: The following records for gravid females are at hand: Aug. 4, 1908 (eggs); Aug. 29, 1910; Sept. 1, 1908 (young glochidia); Sept. 2, 1907; Sept. 6, 1908; Sept. 7, 1908; Sept. 11, 1913; Sept. 13, 1909; Sept. 13, 1915; Sept. 13, 1917; Sept. 15, 1908; Sept. 15, 1915; Sept. 18, 1917; Sept. 21, 1907; Sept. 21, 1908; Sept. 27, 1909; Oct. 4, 1910; Oct. 15, 1907; Oct. 15, 1908; Oct. 19, 1908; Oct. 21, 1908; Oct. 23, 1907. Then again: June 23, 1910 (discharging); Aug. 31, 1906 (discharging).

The beginning of the season is well established as being the month of August, and the discharge takes place in spring and early summer. Probably the (single) discharging individual observed on Aug. 31 was exceptionally belated. The species is positively *bradytictic*.

Remarks: This is an easily recognized species. The subelliptical outline, light brown epidermis, color-markings, and heavy hinge are unmistakable. However specimens of dark color and without rays might be mistaken for *Elliptio dilatatus*, but the interior of the shell generally determines the question.

There is a good deal of variation in shape and color. The humped shape of old shells does not develop in many cases, although on the other hand it may be already in evidence in comparatively small individuals. Specimens from the mountain-streams (Cheat, Loyalhanna, Quemahoning) are much smaller than

usual, and thus there is in the mountains a tendency toward the formation of a small race. Lake Erie possesses a somewhat peculiar form (Plate XIII, fig. 3), in which the specimens remain small; the dimensions of the largest at hand, a gravid female, being: L. 72, H. 40, D. 24 mm., and they assume the humped shape when comparatively small. Further, the growth-lines are more crowded, and more regular, but not very distinct (not marked by color). Young shells of the

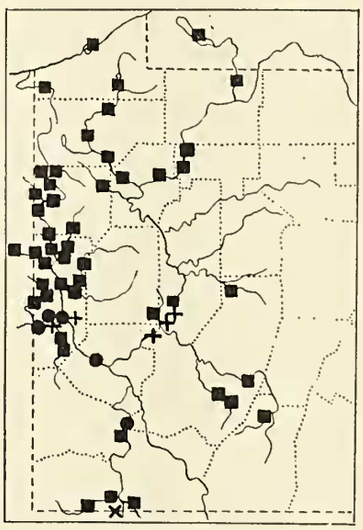


Fig. 22.

■ *Ellipsaria fasciolaris.*
● *Obliquaria reflexa.*
\+ *Cyprogenia stegaria.*
× *Do.* (Indian garbage heap).

form from Lake Erie are indistinguishable from specimens of the same size from the Ohio-drainage. I do not think it advisable to distinguish the lake-form by a varietal name, but the tendency to develope a local race is clearly indicated in this case.

Specimens from Conneaut Creek (tributary to Lake Erie) are entirely normal.

It should be mentioned that the form from Chautauqua Lake in New York inclines toward that of Lake Erie in the more crowded growth-lines, and the average size, a fact which is apparently due to the parallel influence of the environment.

Localities in Pennsylvania, represented in the Carnegie Museum:

Small tributaries of Ohio:

Little Beaver Creek, Cannelton (Miss Vera White & H. H. Smith) and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, New Sheffield, Beaver Co.

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith).
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.

Allegheny-drainage:

Allegheny River, Kelly, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.
Buffalo Creek, Harbison, Butler Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.[140]
Quemahoning Creek, Stantons Mill, Somerset Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.

Monongahela-drainage:

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Lake Erie-drainage:

Conneaut Creek, West Springfield, Erie Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, Vermilion, Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids and Waterville, Lucas Co.; Otsego Rapids, Wood Co.; Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Monroe and Grape P. O., Monroe Co., Michigan (C. Goodrich).

Ohio-drainage:

Lake Chautauqua, Bemus Point (D. R. Sumstine), Griffith Landing (Miss B. Ortmann), and Celoron (P. E. Nordgren), Chautauqua Co., New York.
Tuscarawas River, Ohio (Holland collection).
Ohio River, Toronto, Jefferson Co.; Portsmouth, Scioto Co., Ohio.

[140] Dead shells were seen, but not taken, in the Conemaugh River at New Florence, Westmoreland Co.

Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.

West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn, Lewis Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.

Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.

Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Knox Co., Tennessee (Smith collection).

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).

Paint Rock River, Paint Rock and Trenton, Jackson Co., Alabama (H. H. Smith).

South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, Mascot, Knox Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., and Mendota, Washington Co., Virginia.

Clinch River, Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co.; Fink and Cleveland, Russell Co., Virginia.

Emory River, Harriman, Roane Co., Tennessee.

Powell River, Combs, Claiborne Co., Tennessee.

Distribution and Ecology in Pennsylvania (See fig. 22): In Pennsylvania this is preëminently a species of smaller rivers and creeks. It is very rare in the Allegheny below Oil City, and has not been found in the Ohio. In the Monongahela it must also have been rare. But in the tributaries it is abundant, with the exception of the smallest headwaters. It goes far eastwards toward the divide in Indiana, Westmoreland, and Somerset Counties. It is also found in Cheat River and the upper Monongahela in West Virginia.

Furthermore it occurs in Lake Erie and its tributary, Conneaut Creek, and *may* have crossed into the lake-drainage from the upper Beaver-drainage.

That it avoids large rivers holds good further down the Ohio, although it is not entirely absent there. Its ecological preferences are distinctly for riffles and strongly flowing water, with finer or coarser, but firmly packed gravel. Very frequently it is found along the edges of *Dianthera*-patches, always in a lively current. In Lake Erie it is chiefly found on the North shore of Presque Isle Bay, in two or three feet of water, on sandy or slightly gravelly bottom, exposed to the moderate surf of the bay, but it is not abundant there. Scammon (1906) says that this species prefers (in Kansas) the smaller streams.

General distribution: Type locality, Kentucky River (Vanatta) (Rafinesque gives as habitat the Ohio, Wabash, and Kentucky Rivers).

Simpson (1900) gives its distribution as follows: "Ohio, Tennessee, and Cumberland river systems; peninsula of Michigan; Kansas; Arkansas; Indian Territory; Louisiana." This possibly requires modification with regard to the southwestern range. The most noteworthy feature in its distribution is its absence in the upper Mississippi-drainage. Numerous localities are known from all over Ohio (Sterki, 1907*a*). In Indiana (Call, 1896*a* & 1900) it is found practically all over the state, both in the Ohio and Erie drainages, but it is absent in the Lake Michigan-drainage. As our localities show, it occurs also in West Virginia, and is very abundant in the upper Tennessee region. Wilson & Clark (1914) report it from the upper Cumberland River. In very strong contrast to the foregoing is its scarcity in Illinois. In the latter state it is known only in the southern parts and in the Wabash River (Baker, 1906). Simpson extends the range in a southwesterly direction across the Mississippi. (See also Call, 1895, for Arkansas, and Scammon, 1906, for Kansas.) However, the specimens I have seen from Missouri, Arkansas, and Oklahoma are not typical *E. fasciolaris,* and represent, as has been recognized by Utterback (1916, p. 128) and hinted at by Wheeler (1918, p. 120), a different species. This species is distinct in the rays, which are fine and capillary, and never form blotches.[141]

In a northeasterly direction this species has crossed over into the lake-drainage, going probably by way of the Maumee-route. It has spread over practically the whole lower peninsula of Michigan (as far north as Cheboygan Co.) (See Walker, 1892 & 1898). In Lake Erie it has reached New York at Buffalo (Marshall, 1895). It is clear that the other locality in New York, Chautauqua Lake, was reached from the upper Allegheny.

Two records from Wisconsin and Minnesota are undoubtedly in error and already have been dropped by Simpson.

Genus Obliquaria Rafinesque (1820).

Ortmann, 1912, p. 309; Simpson, 1914, p. 329.

Type *Obliquaria reflexa* Rafinesque.

A monotypic genus.

[141] This species should be called *Ellipsaria occidentalis* (Conrad) (1836) (Currant River, Arkansas), the synonym of which is *Ptychobranchus clintonensis* Simpson (1900) (Archies Fork of the Little Red River, Clinton, Arkansas). *Unio occidentalis* of Conrad has been entirely misunderstood by Simpson (1914, p. 112, as *Lampsilis occidentalis*). The Carnegie Museum possesses material of this form from Missouri, Arkansas, and Oklahoma. Its metropolis is in the Ozark Mountains.

Obliquaria reflexa Rafinesque (1820).

Obliquaria reflexa Rafinesque, Simpson, 1914, p. 330.

Plate XIII, fig. 4.

Records from Pennsylvania:

Clapp, 1895 (Allegheny Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, p. 193.

Characters of the shell: Shell rather small, hardly of medium size, thick and solid. Outline more or less rounded, subovate or subtrapezoidal, short and high, more or less pointed at the lower posterior end. Anterior and lower margins regularly rounded; lower margin ascending posteriorly, straight or slightly concave. Upper margin short, passing in a curve or blunt angle into the obliquely descending posterior margin. Beaks near, but somewhat in front of the middle, elevated over the hinge-line and incurved. Beak-sculpture consisting of a few (two to three) rather heavy, but not sharply defined, concentric bars, which have an indistinct tubercle upon the posterior ridge. Valves flat or convex, with a more or less distinct, rounded posterior ridge, generally with a shallow radial furrow, which may be obsolete. In front of this furrow stands a row of large, prominent knobs, which alternate with each other on the opposite valves. They are rounded, conical, or vertically compressed. Maximum number of these knobs on each valve, four or five. Posterior slope often ornamented with short, corrugated ridges.

Epidermis yellowish to brown, with indistinct darker concentric bands. There may be rays, fine, wavy, or broader; they sometimes spread over the surface, so that the whole epidermis appears dark green. In old specimens the epidermis is often uniformly brown.

Hinge well-developed. Pseudocardinals large, ragged, triangular, two in the left, one in the right valve. Laterals thick and short. Interdentum short and rather narrow. Beak cavity moderate. Dorsal muscle-scars in the beak-cavity. Anterior adductor-scars small, deeply impressed, posterior ones also small and distinct, but less impressed. Nacre silvery white, very rarely colored: I have seen only a few individuals from Alabama with purple nacre.

Sexual differences in the shell very uncertain. On the average, the females are more swollen, with the radial furrow indistinct, and the posterior lower margin not emarginate; while the male shells are more compressed, with the furrow more distinct, and the emargination of the lower margin more frequently developed. These differences, however, are slight, and there are shells in which the sex cannot

positively be determined by these characters. The females seem to remain smaller than the males.

	L.	H.	D.
Size: 1. Industry, Cat. No. 61.4423 (♂)	63 mm.	53 mm.	33 mm.
2. Cooks Ferry, Cat. No. 61.3583 (♂)	56 "	47 "	28 "
3. Shippingport, Cat. No. 61.4756 (♂)	56 "	48 "	27 "
4. Industry, Cat. No. 61.4122 (♂)	46 "	38 "	22 "
5. Industry, Cat. No. 61.3585 (♀)	39 "	33 "	20 "

No. 1 is the largest at hand, surpassing the maximum length given by Scammon (1906).

Soft parts figured by Lefevre & Curtis, 1910, Pl. 1, fig. 3; 1912, Pl. 7, fig. 7; described and figured by Ortmann, 1912, p. 310, fig. 16. *Glochidia* figured by Lefevre & Curtis, 1910, p. 97, fig. M; 1912, p. 146, fig. M; Ortmann, 1912, Pl. 20, fig. 1; Surber, 1912, Pl. 2, fig. 39. According to Lefevre & Curtis the measurements are: 0.225 × 0.230; Surber: 0.225 × 0.235; Ortmann: 0.22 × 0.22 mm.

Breeding season: According to Lefevre & Curtis (1912), and also Surber (1912), the breeding season lasts from May to August: embryos are present from the end of May to July 9, and glochidia from June 20 to Aug. 8. Thus this species would appear to be *tachytictic*.

I have specimens with glochidia (and discharging), collected on May 19, 1911; June 20, 21, 22, 1911; July 13, 1911; July 29, 1914; and Aug. 6, 1910. These accord with the breeding season as given above, with the exception of the first date (May 19). This specimen is from Arkansas. It may be an exceptionally early date, or the breeding season may begin earlier in the South.

It would be well to try to obtain additional data. The species is adapted to a long breeding season. Being a rather primitive form, we may have here primitive or transitional conditions; or on the other hand the breeding season may have been re-adapted to more southern conditions, and may have become irregular.

Remarks: A very peculiar, ancient type in the subfamily, which cannot be mistaken for any other species on account of the peculiar shape and the unique sculpture. It is rather variable in outline and color.

There is a dwarf race in Lake Erie, light in color, which possibly deserves a varietal name; but since this form has not as yet been found in Pennsylvania, I shall not treat of it here.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, Maumee Bay, Toledo, Lucas Co., Ohio; and La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Pocatalico River, Raymond City, Putnam Co., West Virginia.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co., Tennessee.

Western range:

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Spring River, Black Rock, Lawrence Co., Arkansas (A. A. Hinkley).

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Verdigris River, Inola, Rogers Co., Oklahoma (F. B. Isely).

Bayou Pierre, De Soto Parish, Louisiana (L. S. Frierson).

Sabine River, Logansport, De Soto Parish, Louisiana (L. S. Frierson).

Alabama-drainage:

Forks of Black Warrior River, Walker Co., Alabama (H. H. Smith).

Coosa River, Wetumpka, Elmore Co.; Weduska Shoals and Wilsonville, Shelby Co.; Coosa Valley, Riverside, and Lock 4, St. Clair Co.; Fomby Shoals, Calhoun Co.; Greensport, St. Clair Co.; Minnesota Bend, Cherokee Co., Alabama (H. H. Smith).

Distribution and Ecology (See fig. 22): *Type locality,* Ohio River, Letart Falls, Meigs Co., Ohio (Rafinesque).

In Pennsylvania this species is restricted to the large rivers, the Ohio and Monongahela. I found it repeatedly in Beaver County, but it is rather rare. Farther down it becomes more abundant in the Ohio. In general, it seems to be restricted to the Ohio proper and a few of its larger tributaries, as the Muskingum (Dewey, 1856) and Scioto. Sterki (1907*a*) says that it is not found in the Tuscarawas, but in the Mahoning River. However I doubt the latter record, since Dean (1890) does not mention it, and since it is absent in the Beaver and Mahoning in Pennsylvania. The smallest stream in which I found this species, is the Pocatalico River in West Virginia, tributary to the Kanawha, and here it was scarce, and only occurred in the lower part of the stream. In Indiana also this species

is chiefly found in the larger rivers (Ohio, White, Wabash, Kankakee, according to Call, 1896*a* & 1900). It is more abundant in Illinois (Baker, 1906; Forbes & Richardson, 1913), and here it crosses over into the drainage of Lake Michigan (Calumet River, Baker, 1898*a*). It goes up the Mississippi in Illinois and Iowa, and reaches Wisconsin in the Fox River (Barnes, 1823), and southern Minnesota (Grant, 1886; Holzinger, 1888).

Southward it is found in the western tributaries of the Mississippi in eastern Kansas (Scammon, 1906), Arkansas (Call, 1895; Wheeler, 1918), Oklahoma and Louisiana (Vaughan, 1893; Frierson, 1899) and also in eastern Texas (Singley, 1893).

In the southern tributaries of the Ohio it has been reported from the Kentucky River (Rafinesque). It is common in the Cumberland (Wilson & Clark, 1914); and, in the Tennessee, it ascends in the region of Knoxville into the lower Clinch River (Carnegie Museum).

It turns up in the Alabama-drainage (Lewis, 1870 and 1877; Call, 1885; Carnegie Museum), and there goes as far as the Etowah River in northern Georgia (Call, 1885).

In the north it has been reported in Michigan from the Grand and Saginaw Rivers (Walker, 1894 & 1898), and it is also found in Lake Erie in Michigan and Ohio (Sterki, 1907*a*, and Walker, 1913). It has not been found in Pennsylvania, and Call's record (1895, p. 12) from western New York has not been substantiated by positive information. (It does not occur in the list of Marshall, 1895.)

It is clear that the species has crossed over into the lake-drainage from the upper Ohio system; but how it reached the Alabama-drainage remains to be investigated.

It is evident that it prefers large rivers, and it reaches Pennsylvania only in the large streams. According to my observations, it is found chiefly in the deep channel of the Ohio, upon the shell-banks, and is regularly taken by the clam-diggers. Scammon (1906) gives gravel-beds as the favorite habitat. But it seems to be also found on muddy bottoms (Baker, 1898*a*), and Call (1900) says, that it is almost ubiquitous with regard to its habitat. In Pocatalico River I found it in pure, shifting sand.

Genus Cyprogenia Agassiz (1852).

Ortmann, 1912, p. 212; Simpson, 1914, p. 326.

Type *Obovaria stegaria* Rafinesque.

Only one species known from Pennsylvania.

Cyprogenia stegaria (Rafinesque) (1820).

Cyprogenia irrorata (Lea) Simpson, 1914, p. 326; *Cyprogenia stegaria* (Rafinesque) Vanatta, 1915, p. 554.

Plate XIII, fig. 5.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Beaver, Beaver Co.)
Ortmann, 1909*b*, p. 193.

Characters of the shell: Shell hardly of medium size, but solid. Outline subcircular, subtrapezoidal, or rounded triangular. Anterior and lower margins more or less rounded, but the latter tending in the posterior part to be straight or slightly concave. Upper margin short, slightly convex, forming a more or less distinct angle with the posterior margin, which is nearly vertical. Beaks slightly anterior to the middle, moderately inflated and elevated. Beak-sculpture rudimentary, consisting of a few slightly double-looped bars. Valves more or less convex, sometimes making the shell subglobular. Young specimens have a distinct, but rounded, posterior ridge, which becomes effaced in old ones. Generally there is a slight radial groove in front of the ridge, almost effaced in old specimens. Surface adorned by flat nodules, most distinct upon the posterior ridge and in front of the groove. Anterior part of the shell smooth, but there may be nodules in the groove and upon the posterior slope, where they may assume a radial arrangement. In old shells the nodules are much obliterated. The growth-rests are often marked by concentric, low ridges.

Epidermis light green or yellow, to light brown, ornamented with green mottlings, which fall into finer or broader, interrupted rays. The broad rays prevail upon the anterior part of the shell, the fine ones upon the posterior. In old shells the mottlings become indistinct. Concentric color-markings are absent or very faint.

Hinge well-developed. Pseudocardinals heavy, triangular, blunt and ragged, two in left, one in the right valve. Interdentum very broad and short. Laterals rather short, heavy. Beak-cavity moderately deep. Dorsal muscle-scars in the beak-cavity, upon the hinge-plate. Adductor-scars distinct, small, deeply impressed. Nacre silvery white, very rarely with a faint blush of pink.

I cannot see any sexual differences in the shell.

		L.	H.	D.
Size: 1.	Godfrey, Cat. No. 61.4760	62 mm.	57 mm.	38 mm.
2.	do. Cat. No. 61.3581	56 "	54 "	34 "
3.	Industry, Cat. No. 61.4422	54 "	52 "	33 "

I have not seen any larger specimens than No. 1.

The *soft parts* were described and figured by Lea (Obs. I, 1834, Pl. 5, figs. 6, 7), but fig. 7 is wrong; also (Obs. X, 1863, p. 433). Ortmann (1912, p. 313, fig. 17), and Lefevre & Curtis (1912, Pl. 7, fig. 8). The *Glochidia* were described by Sterki (1898, p. 19) and figured by Ortmann (1912, Pl. 19, fig. 6) and also by Surber (1912, Pl. 1, fig. 11). They measure, according to Sterki, 0.21 × 0.17; according to Surber, 0.210 × 0.185; according to Ortmann, 0.18 × 0.15 mm.

Breeding season: The species is *bradytictic* according to Lefevre & Curtis (glochidia in November). Surber found gravid females in October and November. I found them with eggs on Sept. 7 and 12, 1914, and Sept. 14, 1915, and Sept. 17, 1915, and Sept. 24, 1915.

Remarks: A well-marked species, distinguished by its somewhat subglobular shape, nodular surface, and the peculiar, mottled character of the color of the epidermis. The shape, however, is rather variable, and also the development of the nodules. The placentæ are mostly red, but I have found specimens (in Clinch River) with white placentæ.

Localities represented in the Carnegie Museum:

Ohio River, Industry, Beaver Co., Pennsylvania.

Allegheny River, Natrona, Allegheny Co.; Aladdin and Godfrey, Armstrong Co., Pennsylvania.

Tuscarawas River, Ohio (Holland collection).

Little Miami River, Xenia, Greene Co., Ohio (C. Goodrich).

Ohio River, St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio; and Cincinnati, Hamilton Co., Ohio (Juny collection).

Cumberland River, Cloyds Landing and Albany Landing, Cumberland Co., Kentucky (B. Walker, donor).

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith); Knoxville, Knox Co., Tennessee (Hartman collection).

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co., Tennessee.

Distribution and Ecology (See fig. 22): *Type locality*, Ohio River (Rafinesque).

In Pennsylvania this species has been found in the Ohio and lower Allegheny. All specimens collected by myself (only seven) were dead shells, but some of them were quite fresh. However, this species must once have also existed in the Monongahela, at least as far up as the mouth of Cheat River, for I have found specimens in an old Indian garbage heap,[142] opposite Point Marion (See Ortmann, 1909*c*, p. 13).

According to Simpson (1900) it belongs to the Ohio, Cumberland, and Tennessee Rivers, and is mainly restricted to these large rivers, and a few of their larger

[142] Kitchen-midden. *Editor.*

tributaries. Thus, for instance, it occurs in Ohio, in the Muskingum at Marietta (Hildreth, 1828), in the Tuscarawas (Dean, 1890; Sterki, 1907*a*), and in the Scioto and Great Miami (Sterki). Sterki reports it also from the Mahoning River, but it has never been found in the Pennsylvanian part of it, and never anywhere else in the Beaver-drainage. In Indiana it is found besides the Ohio, in the White and Wabash Rivers (Call, 1896*a* and 1900). In Illinois it occurs only in the Wabash (Baker, 1906). A number of localities are known in Kentucky, Tennessee, and northern Alabama in the Cumberland and Tennessee systems (See Wilson & Clark, 1914).

West of the Mississippi it has been reported only by Call (1895) from the St. Francis River, Wittsburg, Cross Co., and Saline River, Benton, Saline Co., Arkansas, but this is questioned by Simpson, and correctly, as I think. I know that this species is represented in this region (Missouri, Kansas, Arkansas, Oklahoma) by another, *C. aberti* (Conrad), which has apparently been mistaken for the one under consideration.

In the Ohio between Pittsburgh and Cincinnati this species is found in the mussel-beds in the deep channel of the river, on gravelly bottoms with steady currents. In the Tennessee-drainage I found it frequently in firmly packed gravel, in strongly flowing water, in rivers of medium size (Clinch, Holston).

Genus Obovaria Rafinesque (1820).[143]

Ortmann, 1912, p. 320; Simpson, 1914, p. 289.

Type *Unio retusa* Lamarck.

The genus is divided into two subgenera.

Key to the Subgenera of Obovaria.

a_1. Shell rounded or subovate, upright, with nearly central, or anteriorly incurved beaks. Pseudocardinals divergent, not parallel to the laterals. Epidermis more or less brown. Nacre often red or purplish. . . . . Subgenus *Obovaria.*

a_2. Shell ovate or elliptical, oblique; beaks quite anterior. Pseudocardinals in adult specimens subparallel to the laterals. Epidermis greenish. Nacre white. . . . . Subgenus *Pseudoön.*

Subgenus Obovaria Simpson (1900).

Ortmann, 1912, p. 321; Simpson, 1914, p. 290.

Type *Obovaria* (*Unio*) *retusa* Lamarck.

Two species and one variety are found in Pennsylvania.

Key to the Forms of Obovaria.

a_1. Shell as high as, or higher than, long. Beaks much elevated and much incurved. Nacre deep purple with white margin. . . . . *O. retusa.*

[143] Not " 1819," as Simpson gives the date. In 1819 Rafinesque published this name, but as " nomen nudum."

a_2. Shell not higher than long. Beaks less elevated and not much incruved. Nacre white or purplish.
b_1. Shell swollen. Diameter sixty percent of the length or more..... *O. subrotunda.*
b_2. Shell compressed. Diameter less than sixty percent of length..... *O. subrotunda levigata.*

Obovaria (Obovaria) retusa (Lamarck) (1819).

Obovaria retusa (Lamarck) Simpson, 1914, p. 290.

Plate XIII, figs. 6, 7.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 192.

Characters of shell: Shell of medium size, heavy and solid. Outline subcircular or subovate, about as high as long, or even higher than long, upright. Anterior, lower, and posterior margins almost regularly rounded, only with a blunt lower posterior angle in the male, and a slight emargination in this region in the female. Upper margin short, convex. Beaks swollen and elevated, situated near the middle of the shell, but strongly incurved forward. Beak-sculpture rudimentary, never distinctly seen by the writer. Valves strongly convex, without a distinct posterior ridge. No sculpture on the outer surface, but irregular concentric ridges, corresponding to the growth-lines, are often present.

Epidermis light to dark brown, generally quite uniformly dark brown upon the disk, while the posterior slope is lighter, pale brown or yellowish. The lighter color is not sharply marked off from the darker part, and often the contrast is not evident at all. Upon the lighter posterior slope, there are sometimes a few feeble greenish rays, and in young specimens, such rays may be indicated by mere traces upon the disk, but normally there are no rays at all.

Hinge well-developed. Pseudocardinals very heavy, stumpy, ragged, triangular, one in right, two in left valve, the latter divergent and not parallel to the laterals. Interdentum broad and short. Laterals short, thick and heavy. Beak-cavity rather deep and narrow. Dorsal muscle-scars upon the inside of the hinge-plate. Adductor-scars distinct and deeply impressed. Nacre of various shades of purple, generally very deeply colored, but the margin outside of the mantle-scar is generally white.

Sexual differences of the shell moderate, but distinctly marked. In the male, the lower and posterior margins form a regular curve or meet in an indistinct, rounded lower posterior angle. In the female the disk shows a slight swelling, forming a slight projection in the posterior part of the lower margin situated at a lower level than the posterior angle of the male. Above this swelling, and behind it, the shell is slightly depressed, and the posterior margin ascends straight or is

somewhat concave, before it reaches the level of the posterior angle of the male. Thus the female shell has two blunt posterior angles on the hind end, but this structure may be rather obscure. The female shell is generally higher than that of the male, and the male seems to grow to a slightly larger size than the female.

		L.	H.	D.
Size: 1.	Industry, Cat. No. 61.3556 (♂)	58 mm.	58 mm.	37 mm.
2.	do. " " 61.3555 (gravid ♀)	58 "	64 "	39 "

Soft parts (See Ortmann, 1912, p. 321, 322, fig. 20). *Glochidia:* Ortmann, 1912, Pl. 19, fig. 9; Surber, 1912, Pl. 3, fig. 47. Measurements: 0.22 × 0.27 (Ortmann); 0.240 × 0.295 (Surber).

Breeding season: On Aug. 29, 1908 and Sept. 7, 1914, I found specimens with eggs, and on Sept. 22, 1910 specimens with glochidia. This indicates the beginning

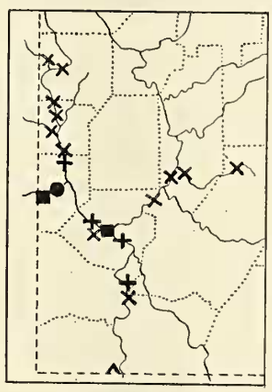


Fig. 23.

● *Obovaria retusa.*
■ *Obovaria olivaria.*
\+ *Obovaria subrotunda.*
× *Obovaria subrotunda levigata.*
> *Obovaria subrotunda levigata* (from Indian garbage heap).

of the season in autumn. Surber (1912) reports this species as gravid in September. It probably is *bradytictic.*

Remarks: There is no trouble in recognizing this species; the shape and the color of the nacre are quite unique.

Localities represented in the Carnegie Museum:

Ohio River, Industry, Beaver Co., Pennsylvania.

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia; (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Tennessee River, Knox Co., Tennessee (Smith collection).

Clinch River, Clinton, Anderson Co., Tennessee.

Distribution and Ecology (See fig. 23): *Type locality,* unknown. The original type locality (Nova Scotia) is erroneous.

Only two specimens have ever been found in Pennsylvania, both at the same place in Beaver Co. This marks the farthest point upstream in the Ohio of the range of this species.

Simpson (1900) gives the range as "Ohio, Cumberland, and Tennessee River systems." To these it seems to be restricted, and in the middle and upper Ohio, it is also restricted to this river, and does not go into the tributaries (For Ohio see Sterki, 1907*a*). In Indiana and Illinois, however, it has spread into the larger affluents. Call (1896*a*, and 1900) reports it for Indiana from the Wabash, White, Whitewater, Patoka, Eel, and Kankakee,[143a] and Baker (1906) gives it for Illinois from the Wabash and Spoon Rivers, as far north as La Salle County. It is also found in the lower Ohio (in Indiana and Illinois), and in the Mississippi River, according to Call (1895, p. 47) "north of Arkansas," but it is missing in Witter's list (1878) of the shells from Muscatine, Iowa, and in Pratt's list (1876) from Davenport, Iowa.

O. retusa is known from the Cumberland River (Wilson & Clark, 1914; also previously reported from Nashville, Davidson Co., Tennessee, by Call, 1895). In the Tennessee it goes up to the region of Knoxville, entering here the lower Clinch.

It is unknown from west of the Mississippi and from the Gulf-drainage, and thus the species is rather restricted in its distribution, and is apparently a form of the larger rivers. In the Ohio between Pittsburgh and Cincinnati I found it associated with the bank-forming shells, and it is here regularly taken by the clam-diggers, but rejected on account of the color of the nacre. In a few cases, I collected it in smaller branches of the Ohio in fine gravel, most abundantly at Portland, Ohio.

Obovaria (Obovaria) subrotunda (Rafinesque) (1820).

Obovaria circulus (Lea) Simpson, 1914, p. 291; *Obovaria subrotunda* (Rafinesque) Vanatta, 1915, p. 552.

Plate XIV, figs. 1, 2.

Records from Pennsylvania:

Lea, Obs. I, 1834 (Monongahela River, Pittsburgh).
Harn, 1891 (western Pennsylvania).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.) (reported as *U. lens*).
Ortmann, 1909*b*, p. 192.

[143a] Also from the Maumee-drainage (St. Joseph River) but this surely needs confirmation. It is also said to be present in a few small lakes in northern Indiana.

Characters of the shell: Shell rather small, but thick and solid. Outline irregularly subcircular, about as high as long, or slightly longer than high, upright. Anterior and lower margins forming a regular curve. Lower margin ascending posteriorly, more or less straight, meeting the obliquely descending posterior margin in a blunt angle in the male. In the female this angle is less distinct, and the posterior margin becomes nearly vertical. Upper margin short, convex. Beaks more or less swollen, slightly elevated, situated close to the middle of the shell, not incurved. Beak-sculpture rudimentary, consisting of about four or five weak bars, slightly sinuated in the middle, angled behind, and disappearing upon the posterior slope. Shell swollen, diameter at least sixty percent of the length. Convexity of valves rather uniform, without any posterior ridge. No sculpture upon the disk.

Epidermis light to dark brown, in young specimens sometimes yellowish green; the disk is generally uniformly dark brown, while the posterior slope is light brown or yellowish, sharply contrasted with the disk, but the contrast becomes less distinct toward the lower margin of the shell. In light-colored young shells, there are sometimes faint traces of greenish rays, but generally rays are entirely absent.

Hinge well-developed. Pseudocardinals strong, stumpy, ragged, triangular, one in right, two in left valve, the latter divergent, and not parallel to the laterals. Interdentum moderate or narrow. Laterals short, strong. Beak-cavity moderately deep. Dorsal muscle-scars partly in the beak-cavity, partly upon the hinge-plate. Adductor-scars distinct, and rather deeply impressed. Nacre silvery white, or with more or less pink or light purple inside of the marginal zone.

Sexual differences in the shell present, but not strongly pronounced, and sometimes obscure. In the male the posterior part of the lower margin ascends and meets the posterior margin in a blunt angle, which, however, may be very indistinct. In the female the lowermost point of the lower margin is situated more backward, and then the margin ascends more suddenly, curving up into the posterior margin more gradually, without forming a distinct angle. Thus the posterior margin appears more vertical, the shell is rather truncate posteriorly, and is rather more elevated. Besides, there is distinctly a difference in size, the female being considerably smaller than the male.

		L.	H.	D.	Pr.ct.
Size:	(Males) 1. Neville Island, Cat. No. 61.1798	59 mm.	52 mm.	38 mm.	.64
	2. do. Cat. No. 61.1598	49 "	45 "	32 "	.65
	(Females) 3. Charleroi, Cat. No. 61.2840	50 "	48 "	34 "	.68
	4. do. " " do.	38 "	37 "	24 "	.63

Soft parts (See Ortmann, 1912, p. 323). *Glochidia* identical with those of var. *levigata*, 0.20 × 0.23 mm., while Surber (1915, p. 7, fig. 8) gives: 0.170 × 0.215 mm.

Breeding season: I found the typical *subrotunda* gravid with glochidia on Sept. 22, 1910, and gravid and discharging on May 25, 1911. A female with eggs was found on Sept. 6, 1914. Surber gives June 9, 1913 for glochidia. This would agree with the *bradytictic* character of the species. A single individual, however, discharging glochidia, was received from A. A. Hinkley, collected on Aug. 9, 1912 in the Wabash River. Probably this specimen was exceptionally belated.

Remarks: The more or less circular outline and subglobular shape, the almost central beaks, and the light color of the posterior slope, serve to distinguish this species. But there is great variability in the outline, and also in the convexity of the valves, and, according to the latter, a variety (*levigata*) must be distinguished from the main species, which will be treated below, and it should be pointed out, that the latter is closely connected with the normal form by intergrades.

Another "species," distinguished by Lea (and Simpson), *O. leibi* (Lea), is nothing but the form from Lake Erie of *O. subrotunda*. It differs merely in its smaller size (largest at hand: L. 42, H. 38, D. 26 mm.), and has, like many lake-forms, more regular and more distinct growth-rests. It is also sometimes lighter in color. I shall not treat of it here in detail, since I have not yet found it on the Pennsylvanian shores of the lake.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Neville Island, Allegheny Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Other localities represented in the Carnegie Museum:

Ohio River, St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).
Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Holston River, Mascot, Knox Co., Tennessee.

Distribution and Ecology (See fig. 23): *Type locality*, Ohio River (Rafinesque). (Vanatta says: "Kentucky River".)

In Pennsylvania the typical *O. subrotunda* is restricted to the Ohio, the Beaver, and the lower Monongahela, and it should be kept in mind, that just in this region more compressed specimens turn up, which establish the transition toward the

var. *levigata*. Farther up only the latter is found, but farther down the Ohio, *O. subrotunda* is common, and goes up into some of the tributaries (Little Kanawha and Elk Rivers). The form from Elk River is peculiar, dwarfed, but with the average diameter of sixty-one percent of the length.[144] Sterki (1907*a*) believes that *circulus* (*subrotunda*) is the male, and *lens* (*levigata*) the female. This is not correct, for relying on Lea's figures, just the opposite would be true. On account of this confusion it is not possible to trace the exact distribution of the two forms in Ohio.

In the rest of the range the two forms have not been kept strictly separate. It suffices here to say, that the range of the true *subrotunda* covers, as Simpson (1900) says: "the Ohio, Tennessee, and Cumberland river systems," that it does not extend west of the Mississippi (Call, 1885), and that it is restricted to larger rivers. This is substantiated by the material in the Carnegie Museum from West Virginia, Kentucky, and Tennessee. Wilson & Clark (1914) report this form from the upper Cumberland.

O. subrotunda has also been reported from the south in the Alabama and Tombigbee drainages (Lea and Lewis, 1870), but this is questioned by Simpson. A few specimens from this region in the Carnegie Museum resemble *O. subrotunda* very much, but I have not enough material to decide the question.

This species also crosses over into the lake-drainage in southern Michigan and Ohio. Specimens from Lake Erie proper form a peculiar race (var. *leibi*), and appear more closely related to *subrotunda*, than to var. *levigata*. In the tributaries of the lake (Maumee-drainage) the var. *levigata* is present. (See below.)

O. subrotunda in the Ohio prefers the shell-banks, in gravel and steady currents. It is also found in small branches of the river, in the gravel of the riffles.

OBOVARIA (OBOVARIA) SUBROTUNDA LEVIGATA (Rafinesque) (1820).

Obovaria lens (LEA) SIMPSON, 1914, p. 293; *Obovaria levigata* (RAFINESQUE) VANATTA, 1915, p. 552.

Plate XIV, figs. 3, 4.

Records from Pennsylvania:

Rhoads, 1899 (specimens from Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 192 (included in *circulus*).

Characters of the variety: Shell similar to that of typical *subrotunda*, but more compressed, the diameter less than sixty percent of the length. Sometimes, but

[144] But in Elk River also the diameter decreases in the upstream direction. At Sutton specimens were found, which should be called var. *levigata* according to the diameter.

not always, the shell is of a lighter color. When lighter, the color is greenish or brownish olive upon the disk, and yellowish upon the posterior slope.

		L.	H.	D.	Pr.ct.
Size:	(Males) 1. Wampum, Cat. No. 61.2842	67 mm.	57 mm.	33 mm.	.49
	2. do. " " do.	60 "	51 "	33 "	.55
	3. do. " " do.	50 "	44 "	25 "	.50
	(Females) 4. Wampum, Cat. No. 61.2842	47 "	44 "	25 "	.53
	5. Natrona, Cat. No. 61.4116	40 "	36 "	22 "	.55
	6. Creekside, Cat. No. 61.3269	37 "	31 "	19 "	.51

The lowest diameter ever observed is in a specimen from West Fork River in West Virginia, where it is forty-six percent of the length.

Soft parts identical with those of *O. subrotunda* (See Ortmann, 1912, p. 328). *Glochidia* figured by Ortmann, 1911, Pl. 89, fig. 15. They measure: 0.20 × 0.23 mm.

Breeding season: Glochidia have been found on Sept. 21, 1908, and again on May 23, 1911; May 24, 1911; and May 27, 1908. On the latter date, discharge has been observed. This indicates, that the form is *bradytictic*.

Remarks: The essential difference between this and the normal form is the compression of the valves. It is true that the color is also often lighter (as pointed out by Lea) but this does not hold good for the average of the Pennsylvanian specimens. As is evident by the measurements given, the diameter of the shell is less than in *O. subrotunda;* but it must be noted, that at certain places the two forms are found associated, and that they actually and insensibly pass into each other. The dividing line at the diameter of sixty percent is entirely artificial, and does not express natural conditions. It has been introduced, as in similar cases, simply for the sake of convenience.

In the smaller creeks, var. *levigata* is found rather exclusively, while *subrotunda* prevails in the Ohio. The transitional zone between them is precisely in the region of Pittsburgh. Thus these forms must be regarded as varieties of one and the same species.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Neville Island, Allegheny Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Natrona, Allegheny Co.; Godfrey, Armstrong Co.
Crooked Creek, Rosston, Armstrong Co.; Creekside, Indiana Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).[145]

Other localities represented in the Carnegie Museum:

Lake-drainage:

St. Joseph River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

Ohio-drainage:

Tuscarawas River; Ohio (Holland collection).
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Sutton, Braxton Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Mud River, Milton, Cabell Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Hurricane Creek, Gurley, Madison Co., Alabama (G. H. Clapp, donor).
Flint River, Maysville, Madison Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Holly Tree, Trenton, and Princeton, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Holston River, Holston Station, Grainger Co., Tennessee.

Distribution and Ecology (See fig. 23): *Type locality,* Kentucky River (Rafinesque).

As has been mentioned above, it is hard to trace the distribution of this form in its relation to *O. subrotunda.* Simpson (1900) gives only: "Ohio-drainage and southern Michigan."

According to my experience this is the small-stream-form of *O. subrotunda,* and wherever the latter tends to ascend into the tributaries of the larger rivers, it turns into *levigata.* This is true in the Beaver-drainage, in the Allegheny and Monongahela in Pennsylvania. But this form is not found in all the tributaries. Upon the whole it is one of the rarer shells in our state. Rather compressed shells are found down the Ohio for a certain distance, but they become scarcer and scarcer. I have traced them down as far as Portland, Meigs Co., Ohio. But since there are only isolated specimens among large numbers of typical *subrotunda,* I have not taken the trouble of picking them out.

[145] This form must have once existed in the Monongahela near Point Marion, Fayette Co., for specimens found in an Indian garbage heap are this (Ortmann, 1909*c*, p. 13). It is abundant in the upper Monongahela system (see below).

In the tributaries of the Ohio in West Virginia it appears to be the rule that *levigata* is the form of the smaller streams. In Ohio aside from the Mahoning River (Dean) this form is positively known to occur in the Tuscarawas River (Dean, 1890, also Carnegie Museum), and it has been reported from the upper Scioto, Columbus, Franklin Co. (Lea), and it has crossed over into the lake-drainage (St. Joseph River).

Further, Call (1885) cites it from Tennessee in Elk River, Lincoln Co., but says that it is identical with "*circulus*." That it is actually there, a little farther up, is shown by specimens in the Carnegie Museum. It also is found in a number of the tributaries of the Tennessee in northern Alabama and northern Georgia, and has been detected in the Holston above Knoxville (very rare at this point).

Ecologically this form is in Pennsylvania and West Virginia distinctly sand-loving. It is found in bars of sand or fine gravel, and is even not averse to shifting sand.

Subgenus PSEUDOÖN Simpson (1900).

Ortmann, 1912, p. 321; Simpson, 1914, p. 298.

Type *Amblema olivaria* Rafinesque.

Only one species is found in Pennsylvania.

OBOVARIA (PSEUDOÖN) OLIVARIA (Rafinesque) (1820).

Obovaria ellipsis (LEA) SIMPSON, 1914, p. 299; *Obovaria olivaria* (RAFINESQUE) VANATTA, 1915, p. 553.

Plate XIII, figs. 8, 9.

Records from Pennsylvania:

Stupakoff, 1894 (Allegheny Co.).
Ortmann, 1909*b*, p. 192.

Characters of the shell: Shell of medium size, thick and solid. Outline elliptical or subovate, longer than high, strongly oblique. Anterior and lower margins forming a regular curve, the lower margin curving up behind, and joining the posterior margin in a curve, without forming an angle, but posterior end of shell more narrowly rounded than the anterior. Upper margin convex, passing gradually into the descending posterior margin. Beaks swollen, directed obliquely forwards, incurved, and located much anteriorly, but generally a little behind the most anterior part of the anterior margin, elevated somewhat above the hinge-line. Beak-sculpture rudimentary, consisting of four or five fine bars, which are sinuate in the middle. The posterior part of the bars is rudimentary and disappears upon

the posterior slope. There are specimens with well preserved beaks, where there is hardly a trace of these bars. Valves rather convex, chiefly so towards the beaks. No posterior ridge developed. No sculpture upon the disk.

Epidermis normally greenish olive, lighter or darker, but shading to yellowish, and in old specimens to brownish olive, but never dark brown. Color generally rather uniform, and growth rests not marked by distinct concentric bands. In some specimens, chiefly young ones, faint green rays are discernible, but rays are mostly absent.

Hinge well-developed. Pseudocardinals heavy and solid, stumpy or slightly elongated, one in right, two in left valve, not distinctly divergent, and becoming, in older shells, subparallel to the laterals. Laterals moderately long, heavy. Interdentum moderately developed. Beak-cavity not very deep. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct and deeply impressed, chiefly the anterior ones. Nacre silvery white.

Sexual differences present in the shell, but not very strongly marked. In the male the lower margin curves up backward from about the middle, and the posterior end of the shell is distinctly narrowed, sometimes almost bluntly pointed. In the female the lower margin begins to ascend at a point back of the middle, and curves up more broadly, so that the shell is less narrowed behind, and the posterior end is broader and more evenly rounded. In consequence of this the female shell appears higher and shorter. The males also grow to a size distinctly larger than the females. However, there are females in which the characteristic shape is poorly developed, and sometimes males are more broadly rounded behind, so that it is not always possible to positively tell the sex by the shape of the shell.

	L.	H.	D.
Size: 1. Industry, Cat. No. 61.3561 (gravid ♀)	66 mm.	54 mm.	36 mm.
2. Cooks Ferry, Cat. No. 61.4420 (♀ ?)	59 "	47 "	34 "
3. Industry, Cat. No. 61.3561 (♀)	42 "	32 "	20 "
4. Toronto, Cat. No. 61.5444 (♂)	76 "	60 "	40 "
5. Portland, Cat. No. 61.4776 (♂)	70 "	55 "	36 "
6. do. " " do. (♂)	60 "	49 "	31 "

Soft parts: Ortmann, 1912, p. 323. *Glochidia, ibid.*, Pl. 19, fig. 11; Surber, 1912, Pl. 2, fig. 25. According to Surber they measure: 0.210 × 0.265; while my figures are: 0.19 × 0.22 mm.

Breeding season: Gravid females were collected: Aug. 29, 1908 (eggs); Sept. 22, 1910 (glochidia); Sept. 24, 1910 (glochidia); and June 20 and 21, 1911 (glochidia, discharging). Although these represent only a few dates, it is clearly shown,

that this is a *bradytictic* form, breeding from August to June. Surber's records also confirm this (1912, p. 7): February, May, June, and August, September, October, November, December.

Remarks: A species easily recognized by the short-elliptical or ovate outline, with the margins more regularly rounded (without angles) than in any other species, by its oblique shape, with much anterior beaks, convex shell, and greenish-olive color. The hinge-teeth are also quite peculiar.

In the outline and convexity of the shell there is much variability, the posterior end being more broadly or more narrowly rounded, and the beaks being more or less anterior. In old shells the beaks are generally more anterior, sometimes even being at the anterior end. The color also is somewhat variable, and old shells are often discolored and dull brown, but not dark brown. In young shells the pseudocardinals are somewhat divergent and not so distinctly parallel to the laterals.

Localities represented in the Carnegie Museum:

Ohio River, Industry and Cooks Ferry, Beaver Co., Pennsylvania.
Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Mississippi River, Moline, Rock Island Co., Illinois (P. E. Nordgren).
Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Distribution and Ecology (See fig. 23): *Type locality,* Kentucky River (Rafinesque).

One of the rarest species in Pennsylvania. It reaches the state only in the Ohio River in Beaver and Allegheny Counties, and does not extend upstream beyond Pittsburgh.

Farther down the Ohio, it is found only in this river, and does not go into the tributaries in the state of Ohio (Sterki, 1907*a*), but it is rather common here. It has a wider distribution in Indiana and Illinois. In Indiana (Call, 1896*a* and 1900) it is practically all over the state, and crosses over into the lake-drainage (Maumee), and goes even farther north into southern Michigan (Detroit, Grand, and Saginaw Rivers, according to Walker, 1892, 1894, and 1898). It has been reported from Lake Erie (Walker, 1913), and also from western New York, Niagara River and Cayuga Lake (Marshall, 1895), and from the lower St. Lawrence in Canada (Ottawa, Montreal, and Quebec, see Marshall, 1895; Bell, 1859; Whiteaves, 1863). However this northeastward expansion of the range is peculiar in its detail, and should

be studied more closely; the species has not been observed on the Pennsylvanian shores of Lake Erie.

Westward, it is abundant in Illinois (Baker, 1906), chiefly in the larger rivers, the Ohio, Wabash, Illinois, Spoon, and Kankakee, and also in the Mississippi, where it is also found on the Iowa side, and goes up to southern Wisconsin (Lapham, 1860) and Minnesota (Grant, 1886, Holzinger, 1888).

Thence westward and southwestward, records are at hand from Missouri (Utterback, 1916), Kansas (Scammon, 1906). Simpson (1900) also mentions the Arkansas River. The Carnegie Museum has it from Black River in northern Arkansas.

South of the Ohio it is found in the Kentucky River (type locality) and in the Cumberland (Wilson & Clark, 1914). It was reported from Nashville, Davidson Co., Tennessee, by Marshall (1895). A single specimen is in the Carnegie Museum from the Tennessee in northern Alabama. Farther up above Chattanooga it is absent. I never saw it there, and it is absent in Lewis' list (1871).

As to its ecology I am able to say from personal experience, that it is a species belonging to the shell-banks of the Ohio, in the deep channels, with strong, steady currents. It is also in the smaller branches in (at low stages) shallow water, in gravel. Scammon (1906) calls it "a lover of water of moderate depth and of sandy river-beds."

Genus Actinonaias Crosse & Fischer (1893).

Nephronaias Crosse & Fischer; Ortmann, 1912, p. 324; *Actinonaias* Frierson, 1917, p. 48.[146]

Type *Unio sapotalensis* Lea.

The only species known from Pennsylvania has been placed by Simpson in *Lampsilis*. But whatever the final name of the genus may be, it is surely not *Lampsilis*, because entirely lacking the characteristic structures found in the female in that genus.

Actinonaias ligamentina (Lamarck) (1819).

Lampsilis ligamentina (Lamarck) and *Lampsilis ligamentina nigrescens* Simpson, 1914, pp. 79 and 82.

Plate XIV, figs. 5, 6.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).

[146] Simpson's *Nephronaias* contains an assemblage of heterogenous species, belonging even to different subfamilies. The nomenclature of this genus is still provisional, the structure of the type-species being as yet incompletely known.

Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 190.

Characters of the shell: Shell large, thick, and heavy. Outline subelliptical or subovate, more or less elongated. Anterior margin rounded, lower margin and upper margin together with the posterior margin forming rather regular curves, joining posteriorly in a blunt point, situated below the horizontal middle line of the shell. Beaks moderately swollen, little elevated, situated anterior to the middle of the shell. Beak-sculpture poorly developed, consisting of a few fine, indistinct bars, which have a tendency to be double-looped. Valves moderately and rather uniformly convex; posterior ridge faint, indistinct, or obliterated. No sculpture upon the disk.

Epidermis yellowish, greenish, or brownish-olive, often with more or less distinct rays. Rays present chiefly in young individuals, broad and continuous, sometimes sharply marked, sometimes obscure, covering the whole shell. In other cases, there are hardly any traces of rays, and in old specimens the epidermis is uniformly brown or blackish. Concentric bands of color are sometimes present.

Hinge well-developed. Pseudocardinals normally one in right, two in left valve, but often additional ones are present. The normal pseudocardinals are strong and heavy, ragged, subtriangular, divergent. Interdentum narrow, rather long. Laterals long, strong, heavy. Beak-cavity moderate. Dorsal muscle-scars in beak-cavity and upon the hinge-plate. Adductor-scars distinct, well impressed, chiefly the one anterior. Nacre silvery white, but often discolored, in very rare cases pinkish.[147]

Sexual differences present, but slight. In the male the lower margin is rather evenly curved. In the female it is more curved out in its posterior part, so that the poterior point of the shell is more elevated, and the whole posterior end of the shell appears higher and more rounded. But in many cases, it is hard, or even impossible, to tell the sex from the shape of the shell. Wherever the posterior expansion is distinctly developed, we may be sure to have a female before us.

	L.	H.	D.
Size: 1. Edinburg, Cat. No. 61.3491 (♀ gravid)	155 mm.	95 mm.	61 mm.
2. Pulaski, Cat. No. 61.4059 (♀)	147 "	94 "	63 "
3. Edinburg, Cat. No. 61.3491 (♂)	124 "	76 "	51 "
4. Cooks Ferry, Cat. No. 61.4791 (♂)	93 "	65 "	41 "

[147] Such specimens have never been found in Pennsylvania, but I have a specimen with pinkish nacre from Blennerhasset Island, near Parkersburg, West Virginia.

Soft parts (See Ortmann, 1912, p. 325). *Glochidia:* Lea (Obs. VI, 1858, Pl. 5, fig. 18) Ortmann (1911*b*, Pl. 89, fig. 16). Surber, 1912, Pl. 2, fig. 18. My measurements are: 0.22 × 0.24; those of Surber: 0.220 × 0.260 mm.

Breeding season: Records for gravid females are rather complete, and cover the period from Aug. 3 to Oct. 24, and from March 21 to May 20. This is a *brady-tictic* form with the interim in June and July. According to Surber (1912, p. 7), glochidia are present from September to July, with the interim in August (in Iowa).

Remarks: Externally a form of simple appearance, without striking characteristics. It may be recognized by its large size and heavy shell, of a rather regular subelliptical outline, with more or less distinct, broad rays. Young shells might be mistaken for *Eurynia iris*, or even for *Lampsilis luteola*, but these latter are both more elongated, and differ somewhat in color.

A. ligamentina varies a good deal. The southern variety, *gibba* of Simpson, is not represented in Pennsylvania. Humped specimens (the character of *gibba*), are found, but they have the earmarks of cripples. The var. *nigrescens* (Simpson, 1914, p. 82) reported from Allegheny County, is merely an individual variation, which is assumed occasionally by old shells, and does not deserve a name.

There are peculiar forms in Arkansas, which generally go by the name of *ligamentina*. They differ from the normal form in the color of the epidermis and of the nacre. I have not made up my mind with regard to these, and in the following list of localities they have been omitted, as has been the var. *gibba*. Only undoubted representatives of *A. ligamentina* are recorded.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Smith's Ferry, Shippingport, Cook's Ferry, and Industry, Beaver Co.; Beaver, Beaver Co. (W. E. C. Todd); Dead Man's Island, Shousetown, and Neville Island, Allegheny Co.; Coraopolis (S. N. Rhoads) and Edgeworth (G. H. Clapp), Allegheny Co.

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White).

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith).

Slipperyrock Creek, Wurtemberg, Lawrence Co.

Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.

Allegheny-drainage:

Allegheny River, Sandy Creek, Harmarville, and Natrona, Allegheny Co.; Braeburn, Westmoreland Co.; Schenley, Aladdin, Godfrey, Johnetta, Kelly, Rosston, Mosgrove, Templeton, and Parkers Landing, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark, Westmoreland Co. (D. A. Atkinson).
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Connewango Creek, Russell, Warren Co.

Monongahela-drainage:

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Youghiogeny River, Boston, Allegheny Co. (D. A. Atkinson).
Cheat River, Cheat Haven, Fayette Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Monroe and Grape P. O., Monroe Co., Michigan (C. Goodrich).
Huron River, Newport, Monroe Co., Michigan (C. Goodrich).
Grand Rapids, Kent Co., Michigan (Hartman collection).

Ohio-drainage:

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
West Fork White River, Riverside, Green Co., Indiana (J. D. Haseman).
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).
Elk River, Shelton and Clay, Clay Co.; Gassaway, Braxton Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Mississippi and westward:

Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).
Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).[148]

Distribution and Ecology in Pennsylvania (See fig. 24): A very common species in western Pennsylvania, but restricted to the larger streams and some of the larger tributaries. In the Ohio, Allegheny, and Monongahela, it is (or was) everywhere present, but in the two latter only up to a certain point. In the Allegheny it goes up to Warren, and beyond, at least as far as Olean, Cattaraugus Co., New York (Marshall, 1895), but is not found in the uppermost part in McKean Co., Pennsylvania. In the Monongahela it has been found as high up as the Cheat,

[148] Mostly normal; but one specimen agrees with one of the Arkansas forms, with dark bold rays, and pink nacre.

but I never have seen it in the upper Monongahela (West Fork River) in West Virginia. Likewise in the tributaries, it only goes up for a certain distance, and then rather suddenly stops. This is the more remarkable, since it is, where present, the prevailing species, outnumbering all other species combined, and then disappears entirely sometimes within a few miles. In the Little Beaver I have never seen it above Cannelton. It is plentiful at Edinburg in the Mahoning, but at Hillsville, a few miles farther up, I saw only a single dead shell, and it is absent

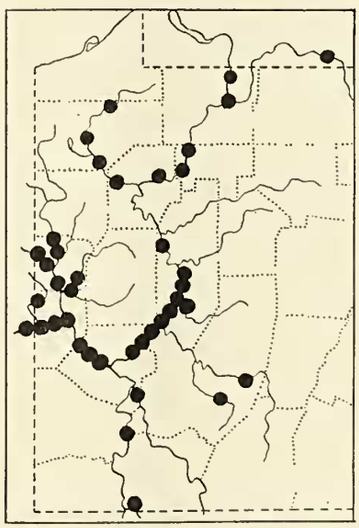


Fig. 24.
● *Actinonaias ligamentina.*

in the Ohio part of this river (Dean, 1890). It is plentiful at Pulaski in the Shenango, but above Sharon there is no trace of it. It goes into the Connoquenessing to Ellwood City, and enters the mouth of Slipperyrock Creek, but is not found farther up. It used to be found in the Kiskiminetas, but our material from this stream is scanty. A dead shell was found in the Loyalhanna at Idlepark. In Crooked Creek it occurs only at the mouth; in French Creek it extends up to Cambridge Springs, and in Connewango Creek as far up as Russell.

Thus it is clear that *A. ligamentina* prefers the larger rivers. It is found here in various environmental conditions, but is apparently best fitted for rough parts, riffles with strong currents and heavy gravel and rocks. Baker (1898*a*) says that it is found in muddy and sluggish rivers in soft mud, but this is decidedly not the case in our region. Call (1900) also calls it a "mud-loving species." In the Ohio below Pittsburgh and far down toward Cincinnati it is the form mainly composing the shell-banks.

General distribution: Type locality, Ohio River (Lamarck).

That this species favors the larger rivers seems to hold good throughout the rest of its range, as well as in Pennsylvania. It is found nevertheless in the northern tributaries of the Ohio in Ohio, Indiana, and Illinois. In this region, it had a chance to cross over into the lake-drainage, and is present in the Cuyahoga River in Ohio (Dean, 1890, Dall & Simpson, 1895), in the Maumee-drainage in Ohio and Indiana (Call, 1896*a*), and in the tributaries of Lake Michigan in Indiana (Call) (See also our material). It is not found in the Michigan-drainage in Illinois, although it ascends in the Desplaines River into the Chicago area (Baker, 1898*a*). It occurs also in the southern part of Michigan (Walker, 1898) in the Lake Erie-drainage, but is not in Lake Erie proper, and not in the lower St. Lawrence-drainage.[149] From Illinois it goes northward into Wisconsin (occurring also in the lake-drainage at Racine, Racine Co., according to Call (1885) and Milwaukee, according to Lapham (1860) and Minnesota (Call, 1885; Grant, 1886; Holzinger, 1888) and here apparently crossing over into the northern drainage in Manitoba (Simpson, 1900) reported from Roseau River by Dawson (1875). Call (1895) mentions it from Dakota, but the particulars are not known. It certainly occurs in Iowa, disregarding the Mississippi (See Call, 1895; Marshall, 1895; Geiser, 1910), and the eastern part of Kansas (Scammon, 1906).

It is also found present south of this range and is known from the southern tributaries of the Ohio in West Virginia and eastern Kentucky, from which specimens are before me. It is commonly reported from the Cumberland and Tennessee-drainages, but here the var. *gibba* turns up, and particulars as to the mutual relation of the distribution of the two varieties are lacking. All the material, without exception, which I collected in the upper Tennessee region in Tennessee and Virginia represents the form *gibba*. Wilson & Clark (1914) say that in the Cumberland River "chiefly the southern mucket" (*gibba*) is found.

From Missouri southward into Arkansas *ligamentina*-forms exist, and *ligamentina* has been reported from Missouri, for instance, by Utterback (1916) and by Wheeler (1918) from the Ouachita in Arkansas. But, as has been stated, different races (at least two of them) are found here, and these require further study. In the Alabama-drainage, this type of Naiad seems to be entirely missing.

[149] Simpson's record from Ontario (1900) is vague, but the Carnegie Museum has it from Ontario north of Lake Erie (Grand River).

Genus Amygdalonaias Crosse & Fischer (1893).

Ortmann, 1912, p. 327; Simpson, 1914, p. 306 (as subgenus of *Plagiola*).

Type *Unio cognatus* Lea.

The nomenclature of this genus must remain provisional, until we know the anatomical structure of the type-species. Two species have been reported from Pennsylvania.

Key to the Species of Amygdalonaias.

a_1. Shell short and high, larger..... *A. truncata.*
a_2. Shell elongated and low, smaller..... *A. donaciformis.*

Amygdalonaias truncata (Rafinesque) (1820).

Plagiola elegans (Lea) Simpson, 1914, p. 307; *Amygdalonaias truncata* (Rafinesque) Utterback, 1916, p. 148.[150]

Plate XIV, fig. 7.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).
Ortmann, 1909*b*, p. 192.

Characters of the shell: Shell rather small, moderately thick. Outline subtriangular-ovate, short and high. Anterior margin rounded, curving into the lower margin, the latter nearly straight posteriorly, and often somewhat concave. Upper margin short, curved, passing in a blunt angle or insensibly into the obliquely descending posterior margin, which joins the lower margin in a more or less distinct angle, so that the posterior end of the shell appears pointed. Beaks more or less elevated, somewhat incurved, situated somewhat in front of the middle. Beak-sculpture rudimentary, consisting of three or four fine bars, the first subconcentric, those following double-looped; the posterior loop is triangularly pointed, and its ascending part on the posterior slope is obsolete. Valves convex, more strongly so in the anterior part of the shell, flattened upon the sides, and often with a faint depression in front of the posterior ridge. The latter is distinct, often elevated and keel-like towards the beaks. The posterior slope appears truncate, slightly convex, flat, or even slightly concave.

Epidermis yellowish brown or greenish, mostly with well-developed rays. Rays wide or narrow, straight. Very often there is a pattern of dark spots upon the rays, which may be arrow-shaped, or wavy, and may extend over a large part

[150] Vanatta (1915, p. 553) does not accept Rafinesque's specific name on account of *Unio truncata* Spengler (1793); however, this does not conflict, since Rafinesque called his species *Truncilla truncata*. See also Walker, 1916, p. 45.

of the surface. In older specimens the color-markings often become obscure, and the epidermis is uniformly brown or blackish.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, triangular, elevated and compressed, ragged. Interdentum quite narrow and short. Laterals moderately long. Beak-cavity moderate. Dorsal muscle-scars in beak-cavity. Anterior adductor-scars distinct and well impressed, posterior ones faint. Nacre silvery white, rarely pinkish.

Sexual differences in the shell very indistinct. Specimens with a more distinct furrow in front of the posterior ridge, and with the posterior section of the lower margin concave, are generally males; while the opposite condition indicates the female sex. In most cases it is very hard to determine the sex from the shell.

		L.	H.	D.
Size: 1.	Neville Island, Cat. No. 61.1761	58 mm.	43 mm.	27 mm.
2.	Industry, Cat. No. 61.3569 (♂)	51 "	40 "	23 "
3.	do. Cat. No. 61.3570 (♂)	46 "	36 "	22 "

No. 1 is one of the largest specimens at hand. No. 2 might be a female according to the shape of the shell, but the soft parts had the male structure.

Soft parts (See Ortmann, 1912, p. 328). *Glochidia:* Lefevre & Curtis (1910, p. 97, fig. 1; 1912, p. 146, fig. 3); Surber (1912, Pl. 2, fig. 30). They are very small: 0.075 × 0.09 mm.

Breeding season: I found only one gravid female, with glochidia, on May 25, 1914. Lefevre & Curtis (1912, p. 141) list this species with the bradytictic forms. Surber (1912, p. 6) states that gravid females with glochidia were found in May and July.

Remarks: The species is easily recognized by its subtriangular shape, its sharp posterior ridge, truncate posterior slope, and the peculiar color-pattern of the epidermis. It only resembles the following species, but is distinguished from that by the higher and shorter shell, which also grows to a larger size. In addition this species has a certain resemblance to the male of *Truncilla triquetra* both in general shape as well as in color. However *Truncilla triquetra* is a more elongated shell, the posterior slope is broader, and more distinctly truncate, and the shell is more inflated.

The posterior ridge of *A. truncata* is quite variable. In Pennsylvania it is not so sharp as elsewhere. From Louisiana, for instance, I have specimens in which it is keel-like. The form from Lake Erie is smaller and lighter, but very variable in color. Having not been found on the Pennsylvanian shores of the lake, I shall not here discuss this form.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport and Industry, Beaver Co.; Neville Island, Allegheny Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, Vermilion, Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Maumee and Erie Canal, Lucas Co., Ohio (C. Goodrich).

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).
Holston River, Hodges, Jefferson Co., Tennessee.
Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee.

West of Mississippi:

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Marais des Cygnes River, Richhill, Bates Co., Missouri (W. I. Utterback).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).
Black River (H. E. Wheeler) and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Verdigris River, Wagoner, Wagoner Co., Oklahoma (F. B. Isely).
Bayou Pierre, De Soto Par., Louisiana (L. S. Frierson).

Distribution and Ecology (See fig. 25): *Type locality,* Ohio River (Rafinesque) (Vanatta says "Falls of the Ohio").

In Pennsylvania this species is rare, and turns up only in the Ohio below Pittsburgh. The few specimens I found there, were found in and below riffles, probably washed out of shells-banks above them.

According to Simpson (1900) this form is generally found in the Mississippi-drainage, but crosses over into the lake-drainage in southern Michigan, Lake Michigan, and Lake Erie (Sterki, 1907*a*, Walker, 1913, and our localities). However it has not been found on the Pennsylvanian shores of Lake Erie.[151] In Ohio

[151] Call (1885) mentions it from western New York which extreme eastern extension might refer to Lake Erie. Marshall (1895) quotes it from Buffalo, but from an entirely unreliable source.

it is also occurs in tributaries to the lake, the Maumee, Tiffin, and Sandusky Rivers (See Sterki). It is found in the Ohio-drainage in Ohio (Sterki), Indiana (Call, 1896*a*, 1900). It is widely distributed in Illinois (Baker, 1906). In the Mississippi, it ascends from Illinois and Iowa to Wisconsin (Lapham, 1860) and as far as Minnesota (Grant, 1886; Holzinger, 1888). It extends down the Mississippi and

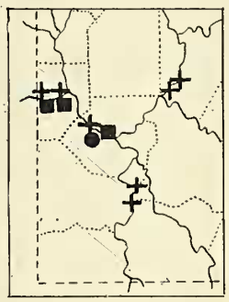


FIG. 25.

■ *Amygdalonaias truncata.*
● *Amygdalonaias donaciformis.*
\+ *Plagiola lineolata.*

to its western tributaries from Missouri (Utterback, 1916) to eastern Kansas (Scammon, 1906), Arkansas (Call, 1895; Wheeler, 1918), Oklahoma (Carnegie Museum), and western Louisiana (Frierson, 1899; Vaughan, 1893), and is found in eastern Texas (Singley, 1893) and as far as Trinity River (Simpson). From the southern tributaries of the Ohio records are scarce, but it is known from the Big Sandy in Kentucky, from the Cumberland (Wilson & Clark, 1914), from Duck River in Tennessee (Marshall, 1895), and from the Tennessee and its tributaries in Alabama up to the Holston and Clinch in eastern Tennessee.

Lewis (1877) cites it from the Alabama-drainage, but this has never been confirmed.

AMYGDALONAIAS DONACIFORMIS (Lea) (1828).

Plagiola donaciformis (LEA) SIMPSON, 1914, p. 308.

Plate XIV, figs. 8, 9.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).

Characters of the shell: Shell much like that of *A. truncata*, but distinguished by the general shape, which is more elongated and less elevated. The posterior ridge, although well marked toward the beaks, is not so sharp as in *A. truncata*, and there is no depression in front of it. Color-markings of the epidermis of the

same general character, but the arrow-shaped spots are more prominent, and often extend over large parts of the shell in a zig-zag pattern.

Male and female shells a little more distinct. In the male the posterior part of the lower margin slopes up in a nearly straight line, rendering the posterior end of the shell more sharply pointed, while in the female the lower margin is more expanded and curved, making the posterior end more bluntly pointed. But there are cases in which the difference is hardly noticeable. Sometimes in the female the posterior part of the lower margin behind the expansion is slightly concave.

		L.	H.	D.
Size: 1.	(No. locality) Cat. No. 61.787 (probably ♂)	49 mm.	34 mm.	20 mm.
2.	do. " " do. (probably ♀)	41 "	26 "	18 "

Soft parts described, but rather unsatisfactorily, by Simpson in (Baker, 1898, p. 91). I find that the soft parts agree completely with those of *A. truncata. Glochidia* (See Surber, 1912, Pl. 2, fig. 29; and Ortmann, 1914, p. 67). They also are remarkable for their small size. Surber's dimensions are: 0.060 × 0.063 mm.; mine are: 0.05 × 0.06 mm.

Breeding season: Surber found eggs and glochidia in July. I received specimens with glochidia collected on Aug. 18, 1912.

Remarks: This species is closely allied to *A. truncata,* and possibly may be only a variety of it. But, as far as I can see, there are no intergrades between them.

This is the only species previously reported from western Pennsylvania, which I have not collected myself. I have seen the specimens collected by Rhoads (now in the Philadelphia Academy), and thus it is beyond doubt that it once existed in our state. It may yet be found on the Pennsylvanian shores of Lake Erie.

Localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, Vermilion (C. Goodrich) and Cedar Point (O. E. Jennings), Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Miami and Erie Canal, Lucas Co., Ohio (C. Goodrich).

Ohio-drainage:

Ohio River, Parkersburg, Wood Co., West Virginia.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Mississippi River and westward:

Mississippi River, Moline, Rock Island Co., Illinois (P. E. Nordgren).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Missouri River, St. Joseph, Buchanan Co., Missouri (W. I. Utterback).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Alabama-drainage:

Coosa River, Weduska Shoals, Shelby Co.; Riddles Bend, Cherokee Co., Alabama (H. H. Smith).

Distribution and Ecology (See fig. 25): *Type locality*, Ohio (Lea).

In Pennsylvania this species has been found only in the Ohio in Allegheny County. It seems to cover about the same range as *A. truncata* (See Simpson, 1900). It goes from Lake Erie down the Ohio, and its tributaries, and up the Mississippi to Minnesota, and westward and southward down and across the Mississippi to Kansas, Oklahoma, and eastern Texas. But in addition it has been reported from Alabama (Simpson) and Coosa River (Call, 1885), and its presence in the latter river is confirmed by specimens in the Carnegie Museum.

It has been referred to as a mud-loving shell by Baker (1898), and as an inhabitant of sand-bars by Call (1900), and of the sandy and muddy beds of rivers, avoiding smaller streams, by Scammon (1906).

Genus Plagiola Rafinesque (1820).[152]

Ortmann, 1912, p. 329; Simpson, 1914, p. 302.

Type *Obliquaria lineolata* Rafinesque.

Monotypic genus.

Plagiola lineolata (Rafinesque) (1820).

Plagiola securis (Lea) Simpson, 1914, p. 304; *Plagiola lineolata* (Rafinesque) Vanatta, 1915, p. 553.[153]

Plate XIV, fig. 10, Plate XV, figs. 1, 2, 3.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Clapp, 1895 (Allegheny Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).
Ortmann, 1909*b*, p. 192.

Characters of the shell: Shell rather large, heavy and solid. Outline triangularly-ovate, generally slightly longer than high. Anterior margin rounded, curving into the lower margin, which is less convex, or nearly straight in its posterior part.

[152] Not 1819. It was published in 1819 as "*nomen nudum.*"

[153] See also Walker, 1916, p. 45.

Upper margin short, convex, continued without any angle into the obliquely descending posterior margin, which meets the lower margin in a distinct, but rounded, lower posterior angle. Beaks moderately elevated above the hinge-line, incurved, located in front of the middle of the shell. Beak-sculpture obscure, consisting of two or three fine and faint, double-looped bars. Valves rather compressed, moderately convex anteriorly, much more flattened on the sides, and peculiarly compressed towards the beaks. Posterior ridge very distinct, although rounded, sharpest towards the beaks. Posterior slope, behind the ridge, narrow, truncate, flat, almost concave towards the beaks, but slightly convex towards the posterior end.

Epidermis greenish yellow to light brown, darker in old individuals, with more or less distinct rays, which are rather narrow, dark brown or dark green, and are generally broken into lunate or squarish, dark spots. In old specimens, the rays may become indistinct, but traces of them and of the spots on them, are in most cases preserved at least in part of the shell.

Hinge well-developed and heavy. Pseudocardinals two in left, one or two in right valve, heavy, ragged. Interdentum well-developed, rather wide and flat. Laterals heavy. Beak-cavity moderate. Dorsal muscle-scars partly in the beak-cavity, partly upon the hinge-plate. Adductor-scars well-developed and rather deep, chiefly the anterior ones. Nacre whitish.

Sexual differences of shell not very great, but generally well-marked. The female shell remains considerably smaller than that of the male, is more inflated, so that the posterior ridge is not so sharp, but there is hardly a difference in the outline, except that the posterior end is more rounded.[154]

		L.	H.	D.
Size:	(Males) 1. Cooks Ferry, Cat. No. 61.3565	118 mm.	91 mm.	51 mm.
	2. do. " " do.	107 "	83 "	49 "
	3. do. " " 61.4421	94 "	74 "	38 "
	(Females) 4. Cooks Ferry, Cat. No. 61.3565 (gravid)	84 "	63 "	40 "
	5. do. " " do. (gravid)	80 "	62 "	38 "
	6. Industry, Cat. No. 61.3568 (gravid)	70 "	59 "	37 "

The above measurements include the maximum records for either sex.

Soft parts (See Ortmann, 1912, p. 329). *Glochidia* (Lea, Obs. VI, 1858, Pl. 5, fig. 8; Lefevre & Curtis, 1910, p. 97, fig. H, and 1912, p. 146, fig. H; Ortmann, 1911*b*, Pl. 89, fig. 17; Surber, 1912, Pl. 2, fig. 14). My (maximum) measurements

[154] Simpson (1900, p. 603) says that the female shell is swollen at the postbasal region. This is hardly correct. The swelling of the female is noticeable chiefly over the lateral faces of the disk, but very rarely in the postbasal region.

are: 0.26 × 0.35 mm.; those of Lefevre & Curtis, 0.23 × 0.31; those of Surber: 0.230 × 0.330.

Breeding season: I have the following dates for gravid females: Sept. 10, 1908; Sept. 12, 1908; Sept. 23, 1908; Sept. 24, 1910; Sept. 25, 1908; Oct. 3, 1908; Nov. 4, 1914; Nov. 17, 1917. Furthermore: Febr. 6, 1911; June 14, 1911; June 20, 1911; June 21, 1911; July 13, 1911. In every case glochidia were present, and on the three days in June, discharging females were present. On July 13 only a single individual, having almost entirely discharged the glochidia, was found. Thus the species is clearly *bradytictic*, and the breeding season probably begins in August and lasts till June or July of the next year. The interim would include part of July and August. Surber's observations agree with this.

Remarks: This species is easily recognized and not liable to be confounded with any other. The subtriangular, compressed shape, with a narrow posterior truncation, and the peculiar color-pattern, are very distinctive characters. The females are quite variable in shape and the compression of the shell is not so striking.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Smiths Ferry (W. F. Graham), Cooks Ferry, Shippingport, and Industry Beaver Co.; and Neville Island, Allegheny Co. (W. F. Graham).

Allegheny River, Godfrey and Kelly, Armstrong Co.

Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Beach Bottom, Brook Co., West Virginia (W. F. Graham); Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Cumberland- and Tennessee-drainages:

Cumberland River, Burnside, Pulaski Co., Kentucky (B. Walker, donor).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Knoxville and Brabsons Ferry, Knox Co., Tennessee.

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Clinch River, Offutt, Anderson Co., Tennessee.

Mississippi river and westward:

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Neosho River, Burlington, Coffey Co., Kansas (R. L. Moodie); Miami, Ottawa Co., Oklahoma (F. B. Isely).

White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Alabama-drainage:

Coosa River, Wetumpka, Elmore Co.; Weduska Shoals and Wilsonville, Shelby Co.; Riverside and Lock 4, St. Clair Co.; Minnesota Bend, Cherokee Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 25): In Pennsylvania this species is found only in the Ohio, Allegheny, and Monongahela. In the Allegheny it goes to southern Armstrong County, where it is quite rare. In the Monongahela it is known only from Charleroi in Washington County, and on the opposite side in Westmoreland County. Below Pittsburgh it is not a rare shell, and has been found in considerable numbers in the riffles and the shell-banks in coarser or finer gravel and in strong currents.

Farther down the Ohio this is a common shell in the shell-banks, and is regularly taken by the clam-diggers.

General distribution: Type locality, Falls of the Ohio, at Louisville, Kentucky (Rafinesque).

This species primarily belongs to the large rivers of the interior basin. In the Ohio its extreme upstream range reaches Pennsylvania. Farther down it is mainly restricted to this river (Sterki, 1907*a*). In Indiana it also occurs in the larger tributaries, the Wabash and West White Rivers (Call, 1896*a*, 1900) and has crossed over, probably very recently, into the Maumee at Fort Wayne, Indiana (Goodrich, 1914). This is the only known record from the lake-drainage. In Illinois it is also found in the Wabash, Kaskaskia, and Illinois Rivers, in the latter as high up as Peoria County (Forbes & Richardson, 1913), and to the Kankakee (Baker, 1906). It ascends the Mississippi as far as Minnesota (Grant, 1886; Holzinger, 1888). It is also found in the Cumberland River (Wilson & Clark, 1912*b* and 1914) and in the Tennessee it goes up according to Lewis (1871) to the "Holston" near Knoxville, but it must be born in mind that the "Holston" of Lewis is the Tennessee. I found it there myself and also in the lower Clinch in Anderson County, but not in the Holston proper.

West of the Mississippi this species is found in Missouri (Utterback, 1916) in southeastern Kansas (Scammon, 1906), Arkansas and Oklahoma (See Call, 1895; Wheeler, 1918; and the material in the Carnegie Museum) but its exact southwestern boundary has not been determined.

In addition it is present in the Alabama and Tombigbee drainages in Alabama (Lewis, 1877; Call, 1885; Simpson, 1900; and material in Carnegie Museum) and has reached Georgia in the Etowah River (Call, 1885).

Everywhere it seems to favor the "mussel-beds" in the larger rivers. Scammon (1906) reports it from rocky riffles in Kansas, but says that it occurs in a

variety of locations, and Call (1900) says that it is found on sand, gravel, and mud-bars, but preferably on the last.

Genus Paraptera Ortmann (1911).

Ortmann, 1912, p. 330.[155]

Type *Unio fragilis* Rafinesque.

Only the type-species is positively known to belong to this genus, although it is probable that several others go with it. The type has been found in our state.

Paraptera fragilis (Rafinesque) (1820).

Lampsilis gracilis (Barnes) Simpson, 1914, p. 181; *Lampsilis fragilis* (Rafinesque) Vanatta, 1915, p. 552; *Lasmonos fragilis* (Rafinesque) Utterback, 1916, p. 152.

Plate XV, figs. 4, 5. 6.

Records from Pennsylvania:

Clapp, 1895 (Allegheny Co.)
Marshall, 1895 (Allegheny River, Warren Co.)[156]
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.)
Ortmann, 1909*b*, pp. 192 and 202.

Characters of the shell: Shell large, but thin. Outline subovate or subelliptical, normally with a high posterior wing, which renders the outline subtriangular. However, this wing may be obliterated, chiefly in old shells. There is also generally a small anterior wing. Shell more or less symphynote at the wings. Anterior margin rounded, united with the upper margin in a sharp angle. Lower margin more or less regularly curved. Upper margin straight, elevated posteriorly, forming the posterior wing and angle. Posterior margin obliquely descending, sometimes somewhat concave just below the upper posterior angle, joining the lower margin in a broad curve, so that there is no posterior angle. Beaks low, hardly elevated above the hinge-line, located in the anterior portion of the shell. Beak-sculpture faintly developed, rudimentary, consisting of three or four fine bars, the first of which is subconcentric, the others double-looped, but only with the

[155] Utterback (1916, p. 151) uses for this genus, the name of *Lasmonos* Rafinesque (1831). However, the type of *Lasmonos* (*L. fragilis* Rafinesque, 1831) is not *Unio fragilis* Rafinesque (1820), but *Unio leptodon* Rafinesque (1820), for which Rafinesque proposed the subgenus *Leptodea* in 1820. Thus *Lasmonos* is a synonym of *Leptodea*. If *U. leptodon* should prove to be congeneric with *Paraptera fragilis*, then, of course, my *Paraptera* should give way, not to *Lasmonos*, but to *Leptodea*.

[156] I doubt the correctness of this locality. In the Allegheny I found this species as far up as southern Armstrong County, where it is very rare. No trace of it was seen above Oil City.

posterior loop distinct, while the anterior is obliterated. Valves rather compressed, moderately and rather uniformly convex, slightly more flattened upon the sides. No distinct posterior ridge. Posterior slope compressed, and even somewhat excavated, chiefly when the upper posterior wing is well developed.

Epidermis smooth, light-colored, pale yellowish to pale greenish, sometimes light olive-brown, with or without greenish rays. When present, the rays are straight, continuous, greenish, rather narrow, and not well-defined. On the posterior slope, the epidermis is lamellar, darker, often with indications of a few stronger rays. Growth-rests generally distinctly indicated by dark concentric bands.

Hinge poorly developed. Pseudocardinals two in left, one in right valve, feeble, subtriangular and lamellar, compressed, often imperfect and represented by mere ridges. Interdentum absent. Laterals long and thin, the lower one in left valve often rudimentary. Beak-cavity shallow. Dorsal muscle-scars in an oblique row in the beak cavity, but rather far from its extreme point. Adductor-scars faintly impressed, the anterior ones more distinct than the posterior ones. Nacre silvery white, in most cases with more or less pink, chiefly towards the beak-cavity; sometimes entirely pinkish.

Sexual differences distinctly marked in the shell. In the male the lower margin is regularly convex, curving up in its posterior half, and the posterior end of the shell is rather narrowly rounded. In the female the lower margin is more expanded in the postbasal region, so that a greater anterior section is descending, while posteriorly it curves up in a very broad curve, rendering the posterior end of the shell more broadly rounded. In the male the greatest height of the shell is located more in the middle of the shell, in the female, it lies in its posterior portion. The posterior expansion of the female is generally extremely thin.

		L.	H.	D.
Size: (Males)	1. Erie, Cat. No. 61.4807	116 mm.	78 mm.	38 mm.
	2. Industry, Cat. No. 61.3549	100 "	62 "	33 "
	3. Erie, Cat. No. 61.4808	99 "	64 "	32 "
	4. Industry, Cat. No. 3549	67 "	42 "	21 "
(Females)	5. Erie, Cat. No. 61.4109	100 "	78 "	32 "
	6. do. Cat. No. 61.4807 (gravid)	84 "	65 "	29 "
	7. Edgeworth, Cat. No. 61.1360	82 "	55 "	23 "
	8. Industry, Cat. No. 61.3549 (gravid)	67 "	46 "	21 "

The largest specimens at hand both from Lake Erie and the Ohio system are given. This species does not reach its maximum size in Pennsylvania, and, as is shown above, the specimens in Lake Erie are larger than those from the Ohio.

Soft parts (See Ortmann, 1912, p. 331). *Glochidia* (See Lefevre & Curtis, 1910, p. 97, fig. K, and 1912, p. 146, fig. K; Ortmann, 1911*b*, Pl. 89, fig. 19; Coker & Surber, 1911, Pl. 1, fig. 2; Surber, 1912, Pl. 2, fig. 28). My measurements are: 0.08 × 0.09; those of Lefevre & Curtis: 0.07 × 0.09; those of Surber: 0.070 × 0.095 mm.

Breeding season: I have the following records for gravid females: Aug. 30, 1909 (beginning to have eggs); Sept. 8, 1908; Sept. 10, 1908; Sept. 11, 1913; Sept. 17, 1913; Sept. 22, 1910; Sept. 25, 1908; Oct. 5, 1909. Then again in spring: May 9, 1913; May 19, 1911; May 22, 1909; May 24, 1911; May 25, 1914; July 7, 1910; July 8, 1910; July 11, 1909. This is a *bradytictic* form, the breeding season beginning in September. A specimen partly charged with eggs was found as early as August 30. Toward the end of September glochidia are found, but eggs have been observed as late as October 5. In spring, in May, glochidia are present, and discharge has been observed on May 22 (in Lake Erie). In the beginning of July the same has been found to be the case, and the latest date for a discharging female, July 11, refers to a specimen from the Ohio River. Thus part of July and August should be regarded as the "interim." There does not seem to be any difference between Lake Erie and the Ohio-drainage.

Surber found glochidia in October, November, January, June, July, and August, and thus it appears that under certain conditions the seasons may overlap in August.

Remarks: A species easily recognized by its subovate, compressed shape and high posterior wing, and, if the latter is reduced, by its yellowish color, thin shell, generally pink nacre, and weak or imperfect hinge-teeth. With regard to the development of the wings there is great variability. Young specimens generally have a well-developed, elevated, posterior wing, and a small anterior wing. But in old specimens the wings may become lower, and are sometimes absent (in many cases evidently broken off). This is chiefly true of specimens from the rivers (Ohio), while the shells from Lake Erie preserve the wings better, even in large individuals. This is undoubtedly due to the environment. The outline of the shell varies greatly with the absence or presence of the wings being more regularly elliptical, or subovate, or even subtriangular. There is also great variability in the hinge, the pseudocardinals being sometimes distinct, sometimes very poorly developed, knob-like, or like low ridges.

Contrary to what has been noted in other cases, the form from Lake Erie is larger and finer than the Ohio form. This is undoubtedly due to the fact, that the river-environment, as developed in western Pennsylvania, is not favorable to this

species, while the lake-environment suits it better. Otherwise there is no difference between the two forms, except that the form from the Ohio river has on the average a somewhat thicker shell and that the lake-form has a stronger tendency to pre-

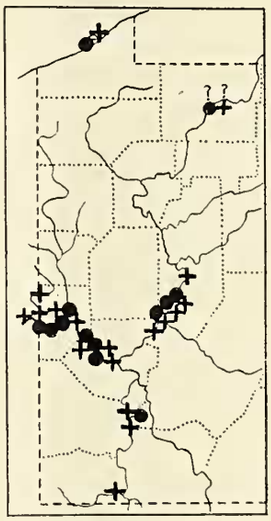


Fig. 26.

● *Paraptera fragilis.*
+ *Proptera alata.*

serve the wings in old shells. But all these peculiarities due to environment are more or less inconstant.

Localities in Pennsylvania, represented in the Carnegie Museum:

Ohio River, Smiths Ferry, Cooks Ferry, Industry, and Beaver, Beaver Co.; Dead Man's Island (Q. T. Shafer, A. T. Shafer, R. Foerster), and Edgeworth (G. H. Clapp), Allegheny Co.

Allegheny River, Aladdin, Godfrey, and Kelly, Armstrong Co.

Monongahela River, Westmoreland Co. (G. A. Ehrmann).

Lake Erie, Presque Isle Bay, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, Vermilion (C. Goodrich) and Cedar Point (C. Brookover), Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Little Kanawha River, Burnsville, Braxton Co., West Virginia.

Pocatalico River, Raymond City, Putnam Co., West Virginia.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).
Tennessee River, Knox Co., Tennessee (Smith collection).
Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.
Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co., Tennessee.
Clinch River, Edgemoor, Anderson Co.; Clinch River Station, Claiborne Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee.

Mississippi River and westward:

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Spring River, Williford, Sharp Co., Arkansas (H. E. Wheeler).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
North Fork Canadian River, Weleetka, Okfuskee Co., Oklahoma (F. B. Isely).
Bayou Pierre, De Soto Parish, Louisiana (L. S. Frierson).

Alabama-drainage:

Buttahatchee River, Hamilton, Marion Co., Alabama (H. H. Smith).
Black Warrior River, Tuscaloosa, Tuscaloosa Co.; Squaw Shoals, Jefferson Co., Alabama (H. H. Smith).
Valley Creek, Toadvine, Jefferson Co., Alabama (H. H. Smith).
Coosa River, Wetumpka, Elmore Co.; near Yellow-Leaf Creek, Chilton Co.; Weduska Shoals and Peckerwood Shoals, Shelby Co.; Coosa Valley and Riverside, St. Clair Co.; Minnesota Bend, Cherokee Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 26): In Pennsylvania, this species has two ranges. On the one hand it belongs to the three large rivers, without, however, going into their tributaries. In the Allegheny it goes only as far as southern Armstrong Co., where it is very rare; in the Monongahela, it has been found only in Westmoreland Co. (opposite Charleroi). On the other hand *P. fragilis* occurs in Lake Erie, where it is rather abundant in Presque Isle Bay. Here it apparently finds most congenial conditions on the sandy shores in from one to three feet of water; but it also has been obtained by the sand-sucker from a depth of ten to fifteen feet.

In the Ohio and Allegheny I found this species chiefly in riffles. Here it is a lively shell, crawling around frequently, and with a speed unusual in other shells. The shells are here not very perfect, and often more or less injured or stunted.

General distribution: Type locality, Ohio River (Rafinesque) (Vanatta says: "creeks in Kentucky").

P. fragilis has an immense range, extending from central Texas (Singley, 1893) north to the Red River of the North, and east and northeast over the whole Mississippi and Ohio drainages, crossing over into the lake-drainage in Wisconsin, Ohio, and Michigan, and going down the St. Lawrence to the Ottawa River (Call, 1885). In this latter region it has extended also into Lake Champlain, and from western New York (Marshall, 1895) through the Erie canal has reached the Hudson River, thus entering the Atlantic watershed. In addition it is found in the Alabama and Tombigbee drainages in Mississippi and Alabama (Lea, Obs. X, 1863; Conrad, 1836; Marshall, 1895). The latter part of the range is not given by Simpson.

It is not necessary to mention particular localities, but the western and southwestern boundaries, and also the northern boundaries, are rather indefinitely known. The records from Kentucky and Tennessee were meagre hitherto, but the species is present in the Cumberland (Wilson & Clark, 1914) and I found it frequently in the upper Tennessee-drainage.

The ecological preferences of this species seem to be for large rivers and lakes, and it avoids smaller rivers and creeks. Its absence from the Tuscarawas River in Ohio, according to Sterki (1907*a*) and from the Beaver in Pennsylvania should be noted. Where I found it in small streams, it was generally in eddies and pools. But, as has been stated, it occurs also on riffles, but possibly it has been in such cases washed out of the deeper and more quiet pools. Previous authors have made similar observations (Call, 1895, 1900; Baker, 1898*a*; Scammon, 1906).

Genus Proptera Rafinesque (1819).[157]

Ortmann, 1912, p. 332; Simpson, 1914, p. 161 (as subgenus of *Lampsilis*).

Type *Unio alata* Say.

Only one species in Pennsylvania.

Proptera alata (Say) (1817).[158]

Lampsilis alata (Say) Simpson, 1914, p. 162.

Plate XV, fig. 7; Plate XVI, figs. 1, 2.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).

Stupakoff, 1894 (Allegheny Co.).

? Marshall, 1895 (Allegheny River, Warren Co.).[159]

[157] This is the only one of the names proposed by Rafinesque in 1819, which has been properly defined. The alate character of the shell has been mentioned, and a type (*alata*) has been given.

[158] Not 1816.

[159] I have never seen a trace of this shell above Oil City, although it is not easily overlooked, and

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, pp. 191 and 202.

Characters of the shell: Shell very large, moderately thick. Outline subovate, but generally with a high posterior wing, which makes the outline subtriangular. This wing is very variable, but rarely (in old shells) indistinct. Sometimes there is an indication of a small anterior wing. Shell symphynote at the wings. Anterior margin rounded. Lower margin slightly convex, or almost straight posteriorly. Upper margin straight, ascending posteriorly, and forming with the posterior margin, the elevated wing-like angle. Posterior margin obliquely descending, slightly concave just below the angle, or straight, and passing in a broad curve into the lower margin, so that there is no lower posterior angle to the shell. Beaks low, hardly elevated above the hinge-line, located in the anterior section of the shell. Beak-sculpture indistinct, feeble, consisting of three or four fine bars, the first subconcentric, the following ones double-looped, with the anterior loop almost effaced. Valves rather compressed, gently convex, flattened upon the sides; no posterior ridge, but shell in this region broadly rounded, with one or two fine radiating, elevated lines. Posterior slope compressed or slightly excavated, elevated into the posterior wing.

Epidermis thick, dark, in young specimens sometimes dark greenish, but generally dark brown to black, without any rays. Mere traces of rays are rarely visible in young specimens. Growth-rests are generally not marked by darker color.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, moderately thick, triangular, ragged. No interdentum. Laterals long, generally curved, moderately strong. Beak-cavity shallow. Dorsal muscle-scars in an irregular, almost vertical row in the beak-cavity. Adductor-scars distinct, the anterior impressed, the posterior less so.

Nacre always purple, generally very dark purple, rarely light purple, and in one case I have seen a pale salmon-color, whitish toward the margins of the shell.

Sexual differences present in the shell, but less marked than in *Paraptera fragilis*. The female is slightly more swollen in the posterior part of the shell, and the lower margin is more broadly rounded in the postbasal region. These differences, however, are slight, and not always reliable. Further, it seems that the female does not attain the extreme size of the male.

if no living shells are found, dead ones are very conspicuous. Its uppermost limit in the Allegheny is Templeton in Armstrong Co., and above Pittsburgh it is in the Allegheny altogether a rare shell.

		L.	H.	D.
Size:	(*Ohio-form*) 1. Wiley, Cat. No. 61.3537 (sex ?)	165 mm.	121 mm.	57 mm.
	2. Godfrey, Cat. No. 61.4107 (♂)	157 "	112 "	44 "
	3. Industry, Cat. No. 61.4416 (♂)	118 "	84 "	33 "
	4. Industry, Cat. No. 61.3538 (♀ gravid)	118 "	79 "	38 "
	5. Cooks Ferry, Cat. No. 61.3540 (♀ gravid)	101 "	78 "	35 "
	(*Lake Erie-form*) 6. Erie, Cat. No. 61.4102 (♀ gravid)	91 "	68 "	36 "
	7. do. Cat. No. 61.3267 (♂)	91 "	65 "	32 "
	8. do. Cat. No. 61.4816 (♀)	87 "	69 "	31 "
	9. do. Cat. No. 61.4817 (♂)	75 "	58 "	25 "

Soft parts (See Ortmann, 1912, p. 333). *Glochidia:* Lea (Obs. VI, 1858, Pl. 5, fig. 25); Lefevre & Curtis, 1910, p. 97, fig. D, and Pl. 4, fig. 25; Ortmann, 1911*b*, Pl. 89, fig. 18; Coker & Surber, 1911, Pl. 1, fig. 3; Lefevre & Curtis, 1912, p. 146, fig. D; Surber, 1912, Pl. 1, fig. 8. My measurements of the glochidia are: 0.20 × 0.38; Lefevre & Curtis give: 0.23 × 0.41; and Surber: 0.220 × 0.380 mm.

Breeding season: The following dates for gravid females are at hand: June 24, 1909 (eggs); August 29, 1908; Aug. 30, 1909; Sept. 6, 1914; Sept. 8, 1908; Sept. 10, 1908; Sept. 15, 1913; Sept. 17, 1908; Sept. 17, 1913; Sept. 23, 1908; Sept. 25, 1908; Sept. 28, 1911; Oct. 3, 1908. Then again in spring: May 21, 1909; May 22, 1914; May 23, 1914; May 24, 1911 (discharging); July 7, 1910 (discharging); July 8, 1910 (discharging); July 11, 1909 (discharging).

The species seems to breed all the year round, and the breeding seasons appear to overlap in June and July. Eggs have been found as early as June 24 (at Kelly) but this might be an exceptional case. At the end of August fully developed glochidia are present. On the other hand discharging females have been found as late as July 11. These extreme dates refer to the Ohio-drainage. In Lake Erie the time for discharging is the same, and I found females in this condition in May as well as in the beginning of July. The beginning of the breeding season has not been observed in the lake.

Remarks: This is a species easily recognized by the large, winged shell, with blackish epidermis, and purple nacre. In its external shape it much resembles *Lasmigona complanata* (Barnes), while on the inside of the shell (hinge and nacre) it is very different from it.

Proptera alata varies greatly in outline, chiefly on account of the variability of the wing. In old specimens, sometimes also in young ones, the wing is almost absent, and often it appears as if broken off in life.

The form from Lake Erie is distinguishable from the Ohio-form. It is smaller, darker brown (not black), has a lighter nacre, and is on the average slightly more swollen. A greater regularity of the growth rests (as is usual in lake-shells) is

not evident in this case. If it should be considered desirable to distinguish the Lake Erie form taxonomically, we should bear in mind that the type-locality for *U. alatus* is Lake Erie, and that the lake-form should retain this name. The form from the Ohio-drainage should then be known as *P. alata megaptera* (Rafinesque) (1820).

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport, Cook's Ferry, and Industry, Beaver Co.; Dead Man's Island (Q. T. Shafer & A. T. Shafer), Coraopolis (S. N. Rhoads), Neville Island, and Edgeworth (G. H. Clapp), Allegheny Co.

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White).[160]

Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).

Dunkard Creek, Wiley, Greene Co.

Lake Erie, Presque Isle Bay, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, Vermilion (C. Goodrich), Cedar Point (C. Brookover), and Sandusky Bay, Cedar Point (O. E. Jennings), Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Maumee River, Roche de Boeuf Rapids, Lucas Co.; Defiance, Defiance Co., Ohio (C. Goodrich).

Ohio-drainage:

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.

Pocatalico River, Raymond City, Putnam Co., West Virginia.[161]

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Brabsons Ferry, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co., Tennessee.[162]

[160] I have seen a dead shell in Little Beaver Creek at Smith's Ferry, Beaver Co.

[161] I have seen dead specimens in Elk River at Shelton and Clay, Clay Co., and at Sutton, Braxton Co., West Virginia.

[162] I have seen a dead specimen in the North Fork of the Holston at Rotherwood, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

Mississippi and westward:

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

Osage River, Warsaw, Benton Co., Missouri (W. I. Utterback).

Bull Creek, Miami Co., Kansas (C. Goodrich, donor) (Osage-drainage).

Kansas and Wakarusa Rivers, Lawrence, Douglas Co., Kansas (R. L. Moodie).

Distribution and Ecology in Pennsylvania (See fig. 26): This species has two ranges in Pennsylvania: one in the Ohio system; the other in Lake Erie. In the latter it is found in Presque Isle Bay, but is comparatively rare.

In the Ohio system, it belongs to the three large rivers, the Ohio, Allegheny and Monongahela, and ascends the Allegheny to Armstrong Co., but is rare there: Marshall's record from Warren County should be disregarded. In the Monongahela, it is known from the neighborhood of Charleroi, but must once have gone farther up, to near the West Virginia state-line, for it is found (although very rarely) in the lower part of Dunkard Creek in Greene Co. There is only one other instance known where it enters a small tributary, this is Little Beaver Creek in Beaver County, and there also it is very rare. None of the other tributaries of the Ohio system contains this species, which is most remarkable especially in the case of the Beaver River, where this species has never been found.

In the Ohio below Pittsburgh *P. alata* is common, sometimes even very abundant, and here it is found in riffles, in fine and often rather coarse gravel. It is a rather active species, crawling around a good deal. It is also found on the shell-banks at Industry and Shippingport, associated with the other bank-forming species, in gravel and strong, steady currents.

In Lake Erie (Presque Isle Bay), it is found in the characteristic sand of the north shore of the bay, in from two to three feet of water, and seems to prefer the open shores (not covered and fringed by rushes).

General distribution: Type locality, Lake Erie (Say).

The centre of distribution is in the northern section of the interior basin, in the Mississippi and Ohio Rivers, and their tributaries. In the Ohio its upper boundary has been located in western Pennsylvania. Like *Paraptera fragilis,* it passes northward into the northern drainage systems of the Red River of the North, of Hudson Bay and of the St. Lawrence. In the latter it is found principally in the lower lakes and their tributaries, as far as Ottawa (Bell, 1859; Whiteaves, 1863) and it also goes into Lake Champlain, Lake George, and the Hudosn-

drainage in New York, Waterford, Saratoga Co. (De Kay, 1843) Troy, Rensselaer Co. (Aldrich, 1869). Compare also Marshall (1895).

Westward it extends to eastern Kansas (Scammon, 1906), and is also present in the southern tributaries of the Ohio in West Virginia, Kentucky, Tennessee (Marshall, 1895; Lewis, 1871; Wilson & Clark, 1914; Carnegie Museum) and northern Alabama (Call, 1885; Carnegie Museum). In the Clinch River it reaches Virginia.

Within the range thus indicated, this species seems to be present chiefly in the larger rivers, but sometimes it is found in rather small streams.[162] Judging from the Ohio below Pennsylvania, it is a species of the shell-banks in the deep channels, and is taken in great numbers by the clam-diggers, but rejected as useless. According to Baker (1898*a*) Call (1900) and Scammon (1906) it lives in the larger lakes and rivers on muddy bottoms, but it certainly is not often found in mud in Pennsylvania, where it occurs mostly in gravel.

Toward the south *P. alata* just reaches Kansas and (in the Tennessee) northern Alabama. Beyond these stations, it is represented by allied, but distinct species or forms. The true *P. alata* is positively missing from the Alabama-drainage. Simpson (1914, p. 164) reports a form from this region, which is also represented in the Carnegie Museum from the Coosa River, called var. *poulsoni* (Conrad). This indeed closely resembles *P. alata*, but in my opinion is a variety of *P. purpurea* (Lamarck). I cannot go into details here, but we have in this case probably to deal with an interesting instance of "convergency."

Genus Toxolasma Rafinesque (1831).

Carunculina Ortmann, 1912, p. 337 (subgenus of *Eurynia*); *Carunculina* Simpson, 1914, p. 148 (subgenus of *Lampsilis*); *Toxolasma*, Frierson, 1914, p. 7; *Carunculina* (genus) Ortmann, 1914, p. 68.

Type *Unio lividus* Rafinesque.[164]

Only one species is known from Pennsylvania.

[163] Its absence in the Tuscarawas River in Ohio has been noticed by Sterki (1907). This corresponds to its absence in the Beaver River in Pennsylvania.

[164] This is the Tennessee-Cumberland form of *U. glans* Lea. Particulars have been published elsewhere.

Toxolasma parvum (Barnes) (1823).

Lampsilis parva (Barnes) Simpson, 1914, p. 151.

Plate XVI, fig. 3.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).[165]
? Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.)[166]
Ortmann, 1909*b*, p. 191.

Characters of the shell: Shell small, but rather solid. Outline subelliptical, with the anterior and posterior ends almost uniformly and broadly rounded. Lower margin gently convex or nearly straight, and almost parallel to the upper margin. Beaks more or less inflated, slightly elevated above the hinge-line, located anterior to the middle of the shell. Beak-sculpture distinct, consisting of five or six comparatively strong, subconcentric bars, of which the later ones are subangular behind. Valves more or less convex, often considerably inflated (chiefly in the female), flattened upon the sides. No distinct posterior ridge. Posterior slope flattened and somewhat compressed.

Epidermis thick, dark, greenish, brown, or blackish, without rays. Growth-rests not indicated by concentric bands.

Hinge well-developed. Two pseudocardinals in left, one in right valve, triangularly projecting, with rough edges. Interdentum absent. Laterals straight, rather long, moderately strong. Beak-cavity moderately deep. Dorsal muscle-scars in beak-cavity. Anterior adductor-scars distinct and well impressed, posterior ones less so. Nacre silvery white.[167]

Sexual differences present in the shell, but not very pronounced. As a rule the male shells are less swollen, while the females are much more so (almost subcylindrical). In the male the posterior end of the shell is narrower, sometimes almost pointed, while in the female it is more broadly rounded and very blunt; but there is great variability in this respect, and only in the older shells are these differences unmistakable.

			L.	H.	D.
Size: 1.	Conneautlake,	Cat. No. 61.3534	32 mm.	19 mm.	15 mm.
2.	do.	Cat. No. 61.4101	30 "	18 "	14 "
3.	do.	" " do.	27 "	17 "	11 "
4.	do.	" " do.	23 "	13 "	9 "

Nos. 2, 3, and 4 are gravid females, and No. 1 also has the shape of a female.

[165] Unfortunately Harn does not give exact locality, so that this record cannot be controlled.

[166] Very likely incorrect, founded upon confusion with *Eurynia fabalis*.

[167] I have a few southern specimens, which have a faint pinkish blush.

Soft parts (See Ortmann, 1912, p. 338). They have been figured by Lea, Obs. VII, 1860, Pl. 29, fig. 102. As to the possible hermaphroditism of this species, see Utterback (1916, p. 165). This question is yet rather obscure. *Glochidia:* Lea (Obs. XIII, 1874, Pl. 21, fig. 3); Surber (1915, fig. 3); Utterback (1916, p. 165). I have seen the glochidia of specimens from Arkansas. They are subovate, higher than long, 0.18 × 0.20 mm. Surber gives: 0.17 × 0.20. In Utterback's figures (0.175 × 0.100) apparently is a misprint.

Breeding season: In Pennsylvania I found three gravid females with eggs on June 17, 1909, which would indicate a very early beginning of the season. But on the other hand I have females from Arkansas with fully developed glochidia collected June 26, 1911, and May 19, 1911. A specimen from Indiana, collected Aug. 9, 1912, had eggs. Surber's glochidia came from a specimen collected July 20, 1911. This is rather confusing, and additional data are much to be desired.

Remarks: The chief characteristics of this species are the small size, rather regular subelliptic outline, the inflated valves, dark epidermis, and beak-sculpture. In Pennsylvania it apparently has been confounded with *Eurynia fabalis*, which resembles it in its small size, but is more compressed, is more pointed behind, has much heavier hinge teeth, and generally more or less distinct rays.

Localities represented in the Carnegie Museum:

Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania.
Lake Erie, Put-in-Bay, Ottawa Co., Ohio (C. Goodrich).
Crane Creek, and Ten Mile Creek, Ottawa Park, Lucas Co., Ohio (C. Goodrich).
Grand Reservoir, Mercer Co., Ohio (C. Goodrich).[168]
Tuscarawas River, Ohio (Holland collection).
Scioto River and Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Wabash River, Mercer Co., Ohio (C. Goodrich); New Harmony, Posey Co., Indiana (A. A. Hinkley).
Big Creek, Solitude, Posey Co., Indiana (A. A. Hinkley).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., and mouth of Cove Creek, Hot Springs Co., Arkansas (H. E. Wheeler).
Big Deceiper Creek, Gum Springs, Clark Co., Arkansas (H. E. Wheeler).
Malvern Creek, Malvern, Hot Springs Co., Arkansas (H. E. Wheeler).
Slough, Tulsa, Tulsa Co., Oklahoma (F. B. Isely).

Distribution and Ecology (See fig. 27): *Type locality,* Fox River, Wisconsin (Barnes).

In Pennsylvania this species is known from but one locality, the outlet of Conneaut Lake. Here I found it in small numbers at a point where a small run

[168] This drains originally into the Maumee, but now into the Wabash at high water.

empties into the outlet, the water of the former being backed up and transformed into a quiet pool. It lives here in mud.

This species has been reported from western New York in the Erie Canal in Onondaga Co., and in the Genesee Canal (Marshall, 1895). It is possible that these localities may later be discovered to be connected with the Pennsylvanian

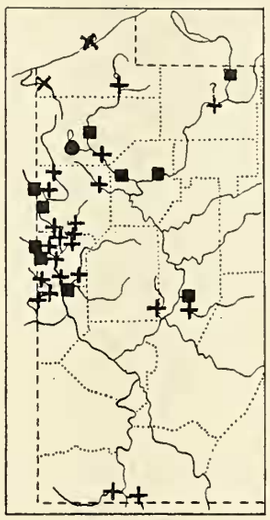


Fig. 27.

● *Toxolasma parvum.*
■ *Eurynia fabalis.*
\+ *Eurynia iris.*
× *Eurynia iris novi-eboraci.*

locality, and this in turn with the western localities, when the species is looked for at favorable habitats (canals, sloughs, etc.). In the state of Ohio it is not rare, and is found in both drainages, and also in Lake Erie (Sterki, 1907*a*; Walker, 1913, p. 21). It is known in the lake-drainage in southern Michigan (Walker, 1898), and is found practically all over Indiana (Call, 1896*a*) and Illinois (Baker, 1906). Here it does not enter the lake-drainage, except in the Maumee River (Call). It is known from Fox River, Wisconsin, from southern Minnesota (Call, 1885; Grant, 1886; Holzinger, 1888), from Iowa (Pratt, 1876; Witter, 1878; Call, 1895; Marshall, 1895; Geiser, 1910). Thence it extends southward, and is found in Missouri (Utterback, 1916), in Kansas (Scammon, 1906), Arkansas (Call, 1895; Wheeler, 1918; see also Carnegie Museum), Oklahoma, and as far south as Texas (Singley, 1893). However, in this region a closely allied species, *T. texasense* (Lea) turns up, and this seems to gradually replace it (see Simpson, 1900, p. 564, footnote 2) and possibly the two forms intergrade. According to Vaughan (1893) they run into each other in northwestern Louisiana.

South of the Ohio in Kentucky and Tennessee definite records are scarce. Wilson & Clark (1914) give it from Stones River in Tennessee, a tributary of the Cumberland. Call reports it (1885) from the Tennessee-drainage near Tuscumbia, Alabama, and from Jackson, Hinds Co., Mississippi. But in this region and also in Alabama it is supposed to be replaced by several other species, the standing of which is very doubtful.

According to Baker (1898*a*) and Scammon (1906), this is a species living buried in mud, in sluggish streams, canals, etc. This is supported by my observations in Pennsylvania.

Genus Eurynia Rafinesque (1820).

Ortmann, 1912, p. 336.[169]

Type *Unio recta* Lamarck.

Four species, and one variety are found in Pennsylvania. They fall into two subgenera.

Key to the Subgenera of Eurynia.

a_1. Inner edge of mantle in front of the branchial opening in the female with irregular, larger or smaller papillæ, generally rather distant from each other. Shell small or of medium size, subovate or subelliptical, not very long (hardly over twice as long as high). Glochidia subspatulate, considerably higher than long. . . . . Subgenus *Micromya*.

a_2. Inner edge of mantle in front of branchial opening in the female with a long row of quite regular, uniform, smaller or larger papillæ, which stand rather crowded. Shell of medium or large size, subelliptical, elongated, distinctly over twice as long as high. Glochidia subovate, only slightly higher than long. . . . . Subgenus *Eurynia*.

Subgenus Micromya Agassiz (1852).

Ortmann, 1912, p. 337.[170]

Type *Unio fabalis* Lea.

Two species and a variety in Pennsylvania.

Key to the Forms of Micromya.

a_1. Shell very small. Hinge-teeth comparatively thick and heavy. Rays faint, broad or fine, often somewhat undulating. . . . . *E.* (*M.*) *fabalis*.

a_2. Shell larger, up to middle size. Hinge-teeth thin and delicate. Rays more or less distinct, not undulating, but often interrupted.

b_1. Rays straight and continuous, often indistinct. . . . . *E.* (*M.*) *iris*.

b_2. Rays interrupted, forming blotches, generally well-developed. . . . . *E.* (*M.*) *iris novi-eboraci*.

[169] *Eurynia* (as subgenus of *Lampsilis*) Simpson, 1914, p. 60, is only in part identical with *Eurynia* in our sense.

[170] The genus *Micromya* of Simpson (1914, p. 32) contains two species, of which only the first (*fabalis*) belongs here. The other species of *Micromya* in our sense stand under *Lampsilis* Simpson.

Eurynia (Micromya) fabalis (Lea) (1831).

Micromya fabalis (Lea) Simpson, 1914, p. 33.

Plate XVI, figs. 4, 5.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Marshall, 1895 (Allegheny River, Warren Co.).
Ortmann, 1909*b*, p. 188.[171]

Characters of the shell: Shell small, but comparatively thick. Outline subelliptical to subovate, rather short, generally a little less than twice as long as high. Anterior and posterior ends rounded. Upper and lower margins more or less curved, the lower sometimes nearly straight, or even concave in the middle. Beaks not much elevated above the hinge-line. Beak-sculpture fine and rudimentary, consisting of four or five bars, which are double-looped and interrupted in the middle. The posterior loop is represented by a mere tubercle. Valves more or less convex, flattened upon the sides. No distinct posterior ridge. Posterior slope slightly convex.

Epidermis yellowish, or light or dark green. Generally covered all over with green rays, but the rays may be absent on the anterior section. The rays are not very sharp, and are broader or narrower, but on the posterior section of the shell they are generally rather narrow, and very often more or less undulating. On the posterior slope they are indistinct. Old shells often incline to a uniform dark green, brown, or blackish color, with very indistinct rays. Growth-rests obscure.

Hinge well-developed. Pseudocardinals two in left, one or two in right valves, comparatively heavy, thick, stumpy, and somewhat crenulated. Interdentum absent or narrow. Laterals moderately long, thick and heavy, especially the one in the right valve, which stands upon a heavy basal plate. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct, and rather deeply impressed, especially the one anterior. Nacre silvery white, sometimes faintly salmon or pinkish toward the beak-cavity; more or less iridiscent posteriorly.

Sexual differences rather well marked. The male shell is not much swollen, and has a long-ovate outline, with the posterior end narrower and more narrowly rounded than the anterior. The lower margin is generally gently curved. In the female shell, which is generally more inflated, the outline is more subelliptical, and the posterior end more broadly rounded than in the male. This is brought

[171] Rhoad's *Unio parvus* (1899) from Beaver River, Wampum, Lawrence Co., refers probably to this species.

about by a slight swelling and prominence of the lower margin in the postbasal region, and in consequence of this the lower margin is straighter in the middle, or even slightly concave. The undulating character of the rays is generally more pronounced in the female in the region of the postbasal swelling. On the average the female shell also appears a little shorter and higher than the male shell.

		L.	H.	D.
Size:	(Males) 1. Utica, Cat. No. 61.3377	37 mm.	20 mm.	12 mm.
	2. Sharpsville, Cat. No. 61.3378	32 "	18 "	10 "
	3. Utica, Cat. No. 61.3377	30 "	16 "	9 "
	4. Rosston, Cat. No. 61.2933	27 "	15 "	9 "
	(Females) 5. Walnut Bend, Cat. No. 61.3376	31 "	18 "	11 "
	6. Russell, Cat. No. 61.3375	29 "	19 "	12 "
	7. Sharpsville, Cat. No. 61.3378	28 "	17 "	11 "
	8. Russell, Cat. No. 61.3375	27 "	17 "	11 "

The largest specimen in the Carnegie Museum is a male (without locality) 40 mm. long.

Soft parts (See Ortmann, 1912, p. 339). *Glochidia* hitherto unknown, but I have seen them in specimens collected in West Virginia. They are of the usual shape, subspatulate, higher than long, but of rather small size. L. 0.17, H. 0.20 mm.

Breeding season: Gravid females were found on May 13, 1911; May 23, 1911; May 23, 1912. In every case glochidia were present. This agrees with the assumption that the species is *bradytictic*. Nothing is known about the beginning of the breeding season.

Remarks: This species, and *Toxolasma parvum*, are the smallest in our fauna, and could not be possibly confounded with any others. The differences of these two have been pointed out under *Toxolasma parvum*. *Eurynia fabalis* can be easily recognized by the combination of a small shell with comparatively heavy hinge teeth, and in this it also differs from the young of other species, for instance *E. iris*. It also has a certain resemblance to young *Elliptio dilatatus*, but the latter is generally longer and thinner, has less heavy teeth, more or less deeply colored nacre, and not the peculiar rays seen in *E. fabalis*.

I have only one specimen from Lake Erie (in Michigan): it is very small (13 mm. long), and has a rather bright green color. I can not tell whether there are any striking differences from the normal type.

Localities in Pennsylvania represented in the Carnegie Museum:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts and Edinburg, Lawrence Co.
Shenango River, Sharpsville, Mercer Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Walnut Bend, Venango Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Meadville, Crawford Co.
Connewango River, Russell, Warren Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Maumee River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

Ohio-drainage:

Tuscarawas River, Ohio (Holland collection).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Elk River, Clay, Clay Co., West Virginia.

Tennessee-drainage:

Holston River, Mascot, Knox Co.; Noeton, Grainger Co.; Church Hill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia.
Clinch River, Clinch River Station, Claiborne Co., Tennessee; Speers Ferry, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Cleveland, Russell Co., Virginia.
Powell River, Combs, Claiborne Co., Tennessee.

Distribution and Ecology in Pennsylvania (See fig. 27): This is a rather rare and local shell in western Pennsylvania, and has been found chiefly in small streams in small numbers. It has never turned up in the Monongahela-drainage in our state, but it is in the headwaters in West Virginia (West Fork River). Probably the species is more abundant than the records show, but is often overlooked, or not hunted for at the proper places. I found it in and near riffles, generally in patches of *Dianthera americana*, or among other water weeds (*Heteranthera*, in the upper Allegheny, or *Potamogeton*, *Vallisneria*, etc.). According to observations made in West Virginia it distinctly prefers these plants, in riffles, and is deeply buried in the sand and gravel bound together by their roots and rhizomes. By pulling up the plants it sometimes was brought to light in goodly numbers.

General distribution: Type locality, Ohio (Lea). This species belongs to the Ohio-drainage, and from this it has crossed over into the lake-drainage in southeastern Michigan and northern Ohio (Conrad, 1836; Marshall, 1895; Sterki, 1907*a*; Walker, 1898). It is also found in the western end of Lake Erie (Walker, 1913, p. 21). It has been reported from western New York, but the only known

locality is Chautauqua Lake (Marshall), and this undoubtedly has been reached from the upper Allegheny. In Indiana (Call, 1896*a*, 1900) it is in the Ohio and Wabash basins, and in some of the lakes in the northern part of this drainage, Tippecanoe (Wilson & Clark, 1912*a*) Winona and Pike (Norris, 1902; Headlee, 1906), and here enters the Lake Michigan-drainage, St. Joseph basin (Call, 1900). From Illinois it has been reported from the Wabash River (Baker, 1906).

It is in the upper Monongahela and Elk River in West Virginia. Records from Kentucky are lacking and Wilson & Clark (1914) do not report it from the Cumberland, but it is known from the Tennessee-drainage in Tennessee, Duck River, Columbia, Maury Co. (Marshall, 1895), and is rather abundant in the headwaters in East Tennessee, going up here to Virginia.

It is unknown to the south and the west of this range.

Little is known as to its ecology. Headlee (1906) gives some particulars with regard to its occurrence in lakes.

Eurynia (Micromya) iris (Lea) (1830).

Lampsilis iris (Lea) Simpson, 1914, p. 113.

Plate XVI, figs. 6, 7.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Simpson, 1900, p. 553 (Beaver River, Pennsylvania) (as *L. fatuus*).[172]
Ortmann, 1909*b*, p. 191.

Characters of the shell: Shell of medium size, moderately thick anteriorly, rather thin posteriorly. Outline subelliptical or subovate, moderately elongated, about twice as long as high. Anterior and posterior ends rounded. Upper and lower margins gently convex, the lower sometimes nearly straight. Beaks not much elevated. Beak-sculpture consisting of four to six fine, but distinct, bars, the first subconcentric, the others distinctly double-looped. Sometimes the later bars become irregular. Valves convex, flattened upon the sides. No distinct posterior ridge.

Epidermis yellowish to light green, with dark green rays. The rays are more or less distinct, sharply or poorly defined, rather narrow, straight, and mostly not interrupted. Often there are concentric bands of color, indicating, in part, the growth-rests.

Hinge well-developed. Pseudocardinals two in left, one in right valve, triangular, a little compressed and crenulated, not heavy. Interdentum absent.

[172] A specimen so labeled by Simpson is in the Carnegie Museum.

Laterals long, thin and narrow. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Anterior adductor-scars distinct and well impressed, those posterior faint and indistinct. Nacre silvery white, highly iridescent posteriorly.

Sexual differences present in the shell, but not always very striking. The male shell has the posterior end more or less attenuated, narrower than the anterior end, and the lower margin has a rather regular curve. In the female shell the lower margin is a little expanded in the postbasal region, so that its middle part is nearly straight, and its posterior part curves up more strongly. In consequence of this, the posterior end of the shell is more broadly rounded, and more nearly resembles the anterior end. There are cases, in which the female character is very slightly developed, and others, where males do not show very well the posterior tapering of the shell. As a rule, however, the sexes are rather easily distinguishable. Female shells seem to be smaller on the average than male shells.

	L.	H.	D.
Size: 1. Edinburg, Cat. No. 61.3531 (probably ♂)	92 mm.	47 mm.	32 mm.[173]
2. New Galilee, Cat. No. 61.1797 (sex ?)	71 "	34 "	22 "
3. New Galilee, Cat. No. 61.3265 (♂)	68 "	36 "	23 "
4. Pulaski, Cat. No. 61.4830 (♂)	55 "	27 "	18 "
5. New Galilee, Cat. No. 61.3265 (♀)	49 "	26 "	17 "
6. Waterford, Cat. No. 61.4096 (♀ gravid)	43 "	24 "	13 "

Soft parts (See Ortmann, 1912, p. 341, fig. 23). *Glochidia* (See Ortmann, 1912, p. 342). They are identical with those of the var. *novi-eboraci* according to Surber (1912, Pl. 3, fig. 46). Surber gives the measurements: 0.240 × 0.300, while I gave: 0.22 × 0.28 mm.

Breeding season: The following records are at hand: Sept. 14, 1909; Sept. 18, 1917; and May 11, 1907; May 13, 1910; May 13, 1911; May 23, 1911; May 24, 1911; July 30, 1914. All my specimens had glochidia. Surber (1912, p. 7) found glochidia in September, and Wilson & Clark (1912) report this species as gravid (in Kankakee River) on July 28, and Aug. 3. All this speaks for a brady-tictic form.

Remarks: This is a shell well characterized by size, shape, and color. It can not be easily confounded with any other Pennsylvanian species. However, young specimens somewhat resemble *E. fabalis,* but are distinguishable at a glance by the relatively thinner shell, and weaker hinge teeth. The extreme brilliancy of the nacre in the posterior section of the shell is also characteristic of this species. The latter character distinguishes *E. iris* also from young *Lampsilis luteola,* which resembles it to some extent. In addition *L. luteola* has more distinctly defined

[173] A giant, and apparently an exceptional case.

rays (if rays occur) and no concentric bands indicating growth-rests, by which fact the young of *L. luteola* may be recognized as being juvenile. Old specimens of *L. luteola* are much larger.

There is a great deal of variability in the character of the rays of *E. iris*, and below I shall discuss a northern race (*novi-eboraci*), the chief difference of which consists in the color-pattern. Otherwise our specimens of *E. iris* are very uniform in their characters.

Localities in Pennsylvania represented in the Carnegie Museum:

Little Beaver Creek, Cannelton (Miss Vera White) and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).[174]
Slipperyrock Creek, Wurtemberg, Lawrence Co.
Mahoning River, Mahoningtown and Edinburg, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Jamestown, Mercer Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Buffalo Creek, Harbison, Butler Co.
Crooked Creek, Rosston, Armstrong Co.
Sandy Creek, Sandy Lake, Mercer Co.
French Creek, Cochranton, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Dunkard Creek, Wiley, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Other localities represented in the Carnegie Museum:

West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton, Clay Co.; and Sutton, Braxton Co., West Virginia.
Little Coal River, Boone Co., West Virginia (Hartman collection).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).

Distribution and Ecology in Pennsylvania (See fig. 27): Like the preceding species (*E. fabalis*) *E. iris* is restricted to the Beaver-drainage and certain tributaries of the Allegheny and Monongahela, and has been found in addition in Little Beaver Creek. It is also present in the upper Monongahela in West Virginia. It has never been found in the large rivers. It seems to prefer localities like those frequented by *E. fabalis* (*Dianthera*-patches), and is altogether a rare shell.

General distribution: Type locality, Ohio (Lea).

The exact range of this species is hard to determine, since it has often been confounded with its var. *novi-eboraci*, and because there are kindred forms in the

[174] One specimen determined by Simpson as *L. fatuus* (Lea).

Tennessee-drainage, which are not well distinguished from it, *e. g.*, *E. nebulosa* (Conrad). Whether it occurs in the state of New York is doubtful, but it might be found in the upper Allegheny-drainage. As the material in the Carnegie Museum shows, it exists in the tributaries of the Ohio in West Virginia. In Ohio it is certainly present, but Sterki (1907*a*) does not separate the two forms. The form from Lake Erie undoubtedly belongs to *novi-eboraci*. It ranges practically all over Indiana (Call, 1896*a* and 1900), and here crosses over into the lake-drainage according to Call. Nevertheless it is quite probable that in northern Indiana its place is taken by the variety; at all events, specimens from Winona Lake in the Carnegie Museum belong to the latter. In Illinois it is reported from the northern half of the state (Baker, 1906), but the common form of the Chicago area is, according to Baker's description (1898) without doubt the var. *novi-eboraci*. Still in this region it may pass into the typical form.

From the foregoing it appears that the typical *E. iris* belongs to the Ohio-drainage in western Pennsylvania, West Virginia, Ohio, Indiana, and possibly Illinois. It may cross over into the lake-drainage, but it seems to be generally represented there by the var. *novi-eboraci*. Farther to the south it seems to be absent. It has indeed been recorded from the Tennessee-drainage, and closely allied forms certainly occur there, but these require further study. A few other records, such as Wisconsin (Simpson), Louisiana and Texas (Baker, 1898) are extremely doubtful.

Strangely enough, it turns up again in the Ozark region in southern Missouri. Utterback (1916) reports it from the basins of White and Black Rivers, and specimens in the Carnegie Museum (James River) are absolutely indistinguishable from Pennsylvanian specimens.

Eurynia (Micromya) iris novi-eboraci (Lea) (1838).

Simpson, 1914, p. 116, makes this a synonym of *Lampsilis iris* (Lea).

Plate XVI, figs. 8, 9.

Records from Pennsylvania wanting hitherto.

Characters of variety: This form differs from the typical *E. iris* by the color-pattern. The rays are not fine and more or less continuous, but rather broad, distinct, and more or less interrupted and dissolved into dark, almost black, squarish spots. These spots are generally arranged in concentric bands, so that the color-pattern becomes very attractive.

		L.	H.	D.
Size: 1.	West Springfield, Cat. No. 61.4091 (♂)	65 mm.	35 mm.	23 mm.
2.	do. " " do. (♀)	51 "	29 "	18 "
3.	do. " " do. (♂)	48 "	28 "	17 "
4.	do. " " do. (♀ gravid)	44 "	24 "	13 "
5.	Erie, Cat. No. 61.4832 (♂)	56 "	32 "	21 "
6.	do. Cat. No. 61.4831 (♀)	56 "	29 "	20 "
7.	do. Cat. No. 61.4833 (♂)	54 "	28 "	17 "
8.	do. Cat. No. 61.4093 (♀)	45 "	25 "	16 "

Soft parts identical with those of typical *E. iris* (See Ortmann, 1912, p. 341). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 14; Ortmann, 1911*b*, Pl. 89, fig. 20 as of *E. iris*).

Breeding season: May 23, 1909, is the only date, at which I found gravid females. They all had glochidia.

Remarks: The color-pattern is the chief diagnostic character of this form. In addition the ground-color of the epidermis is generally lighter than in the typical *E. iris*, but this is not constant. The lake-form differs from that of Conneaut Creek by often (but not always) having the epidermis chestnut-brown especially toward the beaks.

Intergrades seem to be present. Baker (1898*a*) mentioned that the color varies in the Chicago area, and I have transitional specimens from Winona Lake. Even in Lea's types the typical color-pattern is not very well developed.

It should be mentioned, that in shells from the Cumberland and Tennessee drainages belonging to this type, the broken and spotted rays turn up frequently. This will be discussed elsewhere. The geographical relations of these forms which are generally referred to *E. nebulosa* Conrad, are still obscure.

Localities in Pennsylvania represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, Erie, Erie Co.
Conneaut Creek, West Springfield, Erie Co.

Other localities represented in the Carnegie Museum.

Mohawk River, New York (Smith collection).
Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Black Creek, Chili, Monroe Co., New York (R. H. Santens).
Lake Erie, Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich).
Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Raisin River, Grape P. O., Monroe Co.; Adrian and Tecumseh, Lenawee Co., Michigan (C. Goodrich).
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).

Distribution and Ecology (See fig. 27): *Type locality*, Oak Orchard Creek, Orleans Co., New York (Lea).

This form apparently is a northern race of *E. iris*, and is found along the northern edge of the range of the latter in the lake-drainage. Most of the localities known are in the St. Lawrence-drainage in New York (Marshall, 1895, but quoted generally as *iris*). It is known from the Erie Canal, in Onondaga Co., and from Oneida Co., and by this route it may have crossed over into the Mohawk River (Carnegie Museum).

Our records show that it is in Lake Erie and some of its tributaries in Canada, Pennsylvania, Ohio, and Michigan, and very likely the records from this region given by Sterki (1907*a*) and Walker (1913) are to be referred to this variety. In Michigan it is generally distributed, and since Walker (1898) calls it *novi-eboraci* there is no doubt about it.

Farther west its presence is doubtful. It occurs in Winona Lake (Wabash-drainage!), and Baker's figures make it probable that it is found also in the Chicago area, but particulars are lacking.

From Illinois the range certainly extends farther northwestward, as is shown by our specimens from the drainage of the Red River of the North in North Dakota. This locality is altogether new, for even the typical form has been only doubtfully reported from Wisconsin, without exact locality, and has never been found beyond this state.

I found this variety only once in a creek (Conneaut Creek), and here it was abundant in riffles in fine gravel and sand. In Lake Erie it lives in from one to two feet of water on sandy bottom, and often among a scanty growth of rushes (*Juncus americanus*).

Subgenus Eurynia Ortmann (1912).

Ortmann, 1912, p. 338.[175]

Type *Unio recta* Lamarck.

Two species exist in Pennsylvania.

Key to the Species of the Subgenus Eurynia.

a_1. Shell of medium size, rather thin, more or less compressed, with a rather distinct, but rounded posterior ridge. Color of epidermis olive-green to olive-brown. . . . . *E. (E.) nasuta.*

a_2. Shell large, thick, rather swollen, with the posterior ridge obliterated. Color of epidermis dark green to black, rarely brownish. . . . . *E. (E.) recta.*

[175] Simpson's (1914, p. 60) conception of the "subgenus" *Eurynia* differs entirely from ours.

EURYNIA (EURYNIA) NASUTA (Say) (1817).[176]

Lampsilis nasuta (SAY) SIMPSON, 1914, p. 97.

Plate XVI, figs. 10, 11.

Records from Pennsylvania:

Say, 1817 (Delaware and Schuylkill Rivers).
Gabb, 1861 (Schuylkill River and League Island, Philadelphia; "Little Perkiomen Creek").[177]
Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Marshall, 1895 (Philadelphia).
Schick, 1895 (Delaware and Schuylkill Rivers, Philadelphia).
Ortmann, 1909*b*, p. 202, 205.

Characters of the shell: Shell of medium size and medium thickness. Outline subelliptical or sublanceolate, elongated, distinctly over twice as long as high. Anterior margin rounded. Lower margin more or less curved. Upper margin straight or gently curved, forming (at least when young) a distinct angle with the posterior margin, which slopes down obliquely, joining the lower margin in a distinct, but rounded, posterior angle or point. Thus the shell is distinctly attenuated and pointed behind, although the point itself is narrowly rounded. Beaks low, hardly elevated above the hinge-line. Beak-sculpture (Marshall, 1890, fig. 5) consisting of five to seven fine bars, the first one or two subconcentric, the following double-looped, with a distinct re-entering angle or sinus back of the middle. Anterior loop broadly rounded, posterior loop narrow, somewhat angular upon the posterior ridge, and indistinct upon the posterior slope. Valves moderately convex, flattened upon the sides. A posterior ridge is present; it is most distinct near the beaks, and angular, farther downwards it becomes broader, is more rounded and indistinct. Posterior slope slightly concave near the beaks, becoming flatter or even somewhat convex toward the posterior end of the shell. In young shells it is compressed and elevated toward the posterior angle of the upper margin.

Epidermis dark olive-green or brown, with or without rays. The latter are poorly developed, dark green, straight, narrow or somewhat wider, and generally visible only (if at all) in the posterior section of the shell, just in front of the posterior ridge, and upon the posterior slope. In younger specimens the rays may extend over the whole surface. In other cases, they are entirely absent. Sometimes there are concentric light and dark bands, the latter marking the growth-rests.

[176] Not 1816.

[177] Perkiomen Creek is a tributary of the Schuylkill in Montgomery County. There is no "Little Perkiomen Creek" to my knowledge.

Hinge well-developed. Pseudocardinals one or two in left, one or two in right valve, not very large and not heavy, compressed, subtriangular, somewhat crenulated. Laterals long and thin. No interdentum. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct, and moderately impressed anteriorly, less distinct posteriorly. Nacre silvery white, often cream-color or salmon toward the beak-cavity, highly iridescent posteriorly.

Sexual differences of the shell well marked. In the male the shell tapers uniformly behind into the posterior point, and the lower margin has a rather uniform curve. In the female the lower margin is distinctly produced in the postbasal portion, there forming a broad, rounded projection, behind which the lower margin slopes up more suddenly, and is at this point straight or even slightly concave.[178]

	L.	H.	D.
Size: 1. Yardley, Cat. No. 61.3525 (largest ♂)	77 mm.	35 mm.	19 mm.
2. Erie, Cat. No. 61.4088 (♂)	102 "	44 "	30 "
3. do. Cat. No. 61.4837 (♀)	93 "	45 "	27 "
4. do. Cat. No. 61.4083 (♂)	89 "	42 "	24 "
5. do. Cat. No. 61.4088 (♀)	71 "	33 "	17 "
6. do. " " do. (♀)	58 "	28 "	15 "

Soft parts (See Ortmann, 1912, p. 343). *Glochidia* (See Lea, Obs. XIII, 1874, Pl. 21, fig. 2; Ortmann, 1912, Pl. 20, fig. 8).

Breeding season: Conner (1907) mentions this species as breeding all the year round. From the eastern part of the state I have only two records for gravid females: Sept. 15, 1905 and May 10, 1909, in both cases with glochidia. From Lake Erie I have the following records: end of August, 1909 (eggs), and May 21, 1909; May 22, 1909; May 24, 1909; June 2, 1908; June 3, 1908; July 7, 1910. The dates in early summer furnished glochidia, and on the two last ones, discharging females were found. On and after July 8 numerous females were collected, but none were gravid, so that in Lake Erie, as I have shown (1912, p. 343), a distinct interim exists in July and at the beginning of August.

Remarks: This is a species quite easily recognized by its lance-head outline, dull olive-green color, with only indistinct rays, and light-colored nacre. However, it resembles, principally in the male sex certain other species, for instance *Elliptio cupreus* (Rafinesque) and *E. fisherianus* (Lea), and indeed, specimens of the latter have been confounded by Conrad with it. *E. cupreus* and *E. fisherianus* generally have a differently colored nacre (coppery or purple), and differ in the

[178] In old males, there is sometimes a short concavity of the lower margin immediately in front of the posterior end. This is due to a downward deflection of the posterior end, such as is often observed in old specimens of other species.

hinge-teeth, which are more stumpy. The females of these two are entirely different from those of *E. nasuta*, and have never the peculiar expansion of the lower margin.

There is not much variability in *E. nasuta*. The specimens may be a little longer or shorter in outline, and the color of the epidermis may be more greenish or more brownish. In this connection it should be mentioned that specimens from Lake Erie frequently differ from eastern specimens by their rusty brown

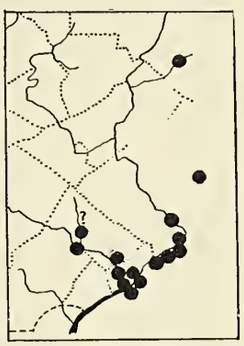


FIG. 28.

● *Eurynia nasuta* (eastern range).

color, especially towards the beaks. This is the effect of the lake environment, which is observed in other species from the lake. But this color is not always present. As usual, specimens from Lake Erie often have very regular growth-rests. In all other characters, the lake-form is absolutely like that of eastern Pennsylvania.

Localities in Pennsylvania represented in the Carnegie Museum:

Lake Erie, Miles Grove, and Presque Isle Bay, also beach-pools of Presque Isle, Erie, Erie Co.
Delaware River, Penns Manor and Yardley, Bucks Co.
Schuylkill Canal, Manayunk, Philadelphia Co.

Other localities represented in the Carnegie Museum:

Douglas Lake, Cheboygan Co., Michigan (H. B. Baker).
Otter Creek, Monroe Co., Michigan (C. Goodrich).
Ottawa River, Toledo, Lucas Co., Ohio (C. Goodrich).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Sandusky Bay, Cedar Point, Erie Co., Ohio (O. E. Jennings; C. Brookover); Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich); Crystal Beach, Welland Co., Ontario, Canada (F. Behrle).
Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Delaware River, Fish House, Camden Co., New Jersey.

Localities represented in the Philadelphia Academy:

Delaware River, Kaighn's Point, Camden, Camden Co., New Jersey (John Ford); Delanco (H. A. Pilsbry), Burlington Island (H. W. Fowler), and Florence (H. W. Fowler), Burlington Co., New Jersey.

Swartswood Lake, Sussex Co., New Jersey (H. A. Pilsbry & S. N. Rhoads), drains to Delaware River.

Cohansey Creek, Bridgeton, Cumberland Co., New Jersey (S. N. Rhoads) coastal plain of southern New Jersey.

Potomac River, Washington, D. C. (John Ford); Alexandria, Fairfax Co., Virginia (G. W. Tryon, Jr.).

Distribution and Ecology in Pennsylvania (See figs. 28 & 29): In Pennsylvania this species has two ranges: one in the extreme eastern end of the state, and the other in the northwest, in Lake Erie. Its metropolis in the east is found in the tidewaters of the Delaware River; farther up (above Trenton, New Jersey) it is

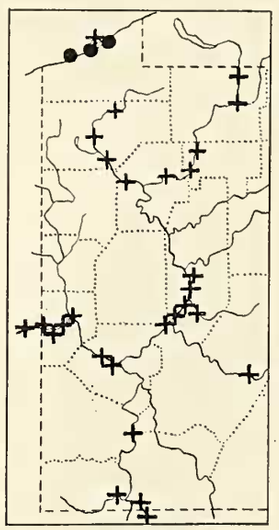


Fig. 29.

● *Eurynia nasuta* (western range).
\+ *Eurynia recta.*

rare. It also has been reported from the Schuylkill, probably its lower part, as far up as Chester Co. The record from Perkiomen Creek in Montgomery Co. is doubtful (See above). In addition I found a single individual in the Schuylkill Canal. It has never been found in any of the smaller tributaries, and no records are at hand from anywhere in the Susquehanna or Potomac drainages in Pennsylvania.

I found it in large numbers in the tidewater of the Delaware opposite Philadelphia at Fish House. Here it inhabits the shores of the Delaware, which resembles rather a lake than a river. The bottom at this point is fine sand, and the

water is subject to the tides. At Penn's Manor I found it in the deep water of a protected cove, on a bottom consisting of mud and vegetable debris. The single specimen from the Schuylkill Canal was in deep black muck, the only one found at Yardley lived in gravel in an eddy in a riffle.

In Lake Erie it is a very common species in Presque Isle Bay, where it is present in all parts on sandy, gravelly, and muddy bottom, in from one to fifteen feet of water, and it is also abundant in certain beach-pools of Presque Isle, on sandy and sandy-muddy bottom.

Sandy bottom of great, quiet bodies of water (tidewaters, lakes and probably also canals) seem to furnish the conditions most favorable to this species.

General distribution: Type locality, Schuylkill and Delaware Rivers, Philadelphia (Say).

The distribution of this species is unique: only *Elliptio violaceus* can be compared with it, but even this is by no means identical (See under *E. violaceus*, p. 110, and Walker, 1913). It is found on the Atlantic coastal plain, but does not go far up into the rivers, at least in the southern part of its range. Although Simpson (1900) reports it as far South as North Carolina, I have been able to find as its most southern record only that of Conrad (1836) from James River, Virginia (the figured specimen is from this place). Conrad also gives the Potomac river at Washington, and this is confirmed by other writers (Dewey, 1856; Marshall, 1895) and by specimens in the Philadelphia Academy. It is not known from anywhere in the headwaters of the Atlantic streams in Virginia and Maryland, and I myself never found it in the upper James, the upper Rappahannock, and the Potomac, on the Piedmont Plateau and West of the Blue Ridge. It has been reported from the lowlands in Delaware (Rhoads, 1904). In Pennsylvania its distribution is restricted chiefly to the lowlands, and it is absent in the upper Susquehanna. In New Jersey it is known from the Delaware River and from the coastal plain (Philadelphia Academy). I found it in the Delaware-Raritan Canal, and in addition there is a locality (given above) in Sussex Co., northern New Jersey, belonging to the upper Delaware-drainage, which is highly interesting. It is found in New York in the Hudson River as far up as Troy and Albany (Aldrich, 1869; Marshall, 1895[179]), and a number of localities are known from Connecticut, Rhode Island, and Massachusetts (Linsley, 1845; Perkins, 1869; Carpenter, 1890; Earle, 1835; Gould-Binney, 1870; Marshall, 1895; Johnson, 1915). It goes northward to Keene, Cheshire Co., New Hampshire (Walker & Coolidge, 1908).

From the Hudson-drainage in New York, this species ranges westward through the Mohawk basin and the Erie canal, and enters the St. Lawrence-drainage.

[179] Marshall also gives Delaware River, but no exact locality.

Here it is found in the tributaries of Lake Ontario in New York, and in Hamilton Bay of Lake Ontario in Canada (DeKay, 1843; Marshall, 1895), and reaches the Niagara River and Lake Erie (Marshall). In Lake Erie it extends farther westwards, along the Canadian (Carnegie Museum) Pennsylvanian and Ohio shores (Sterki, 1907*a*; Walker, 1913). In Ohio it is found also in tributaries of the lake in Portage Co. (Dean, 1890, Sterki) and Cuyahoga River (Dean, 1890), and in Ottawa River, Lucas Co. (Carnegie Museum).[180] Further it is found in Michigan over the whole state (Walker, 1898). Call (1896*a*) reports it also from the St. Joseph basin in Indiana, but in 1900 (p. 458) he says that no authentic specimens are known from this state. Farther to the south and west it seems to be replaced by the closely allied *E. subrostrata* (Say).

The western and the eastern ranges seem to be connected from Lake Erie to the Hudson River by the Erie canal, and it is very likely that this species migrated along this route.[181] The direction of the migration probably was from west to east, considering the fact that the only closely allied species, *Eurynia subrostrata*, is a species of the interior basin. Being a species partial to quiet water, it is only natural that it followed the route of the Erie canal. In this case, however, this migration must have been quite recent, and it must be a very late arrival on the coastal plain, where it has spread in recent times, as far South as Virginia, remaining restricted chiefly in the southern part of its range to the Coastal plain. This has been discussed previously in another paper (Ortmann, 1913*a*, p. 378 *et seq.*).

Eurynia (Eurynia) recta (Lamarck) (1819).

Lampsilis recta (Lamarck) Simpson, 1914, p. 95.

Plate XVI, figs. 12, 13.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Clapp, 1895 (Allegheny Co.)
Marshall, 1895 (Allegheny River, Warren Co.)
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.)
Ortmann, 1909*b*, pp. 190 and 202.

Characters of the shell: Shell large, solid and heavy. Outline subelliptical to sublanceolate, elongated, distinctly over twice (up to two and a half times) as long as high. Anterior margin rounded; lower margin more or less convex. Upper margin nearly straight, passing gradually into the descending posterior

[180] Sterki says: "probably also in the Ohio-drainage, at least along the divide."

[181] This route is more southern than that of *Elliptio violaceus*, where the connection does not go through Lake Erie but is more northern.

margin, which joins the lower margin in a distinct, but rounded, angle, so that the shell is more or less narrowed and pointed at the posterior end. Beaks low, only little elevated above the hinge-line. Beak-sculpture faint and obsolete, consisting of three to five indistinct bars, which are double-looped, with a sinus in the middle; the posterior loop is open, *i.e.*, the bars disappear upon the posterior slope. Valves moderately convex, flattened upon the sides. Posterior ridge practically absent, only toward the beaks is it faintly indicated. Posterior slope gently convex, flat towards the beaks.

Epidermis glossy, dark green to brown or blackish, with indistinct rays or without rays. Young shells are lighter green, with dark green rays of various width, but in the posterior section of the shell the rays are generally rather wide. In old shells, the rays become obscure, and the epidermis is often uniformly dark brown or black. Sometimes concentric bands of dark color, marking growth-rests, are present, but generally the growth-rests are not marked by color.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, stumpy or slightly compressed, crenulated. No interdentum. Laterals long, strong, rather straight. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct, those anterior well impressed, those posterior less so. Nacre white, iridescent posteriorly. Often there is more or less pink or light purple in the beak-cavity and upon the hinge teeth; sometimes all of the nacre is purple, but such specimens have not been found in Pennsylvania.

Sexual differences of shell well marked. In the male, the shell tapers posteriorly rather uniformly to a point, and the posterior part is distinctly narrower than the anterior. In the female, the lower margin is distinctly enlarged in the postbasal part. In front of this widening, the lower margin is straight or slightly concave, behind it slopes up rather suddenly to the posterior point, which, in consequence of this, is more elevated above the base line than in the male. The posterior section of the female shell is not distinctly narrowed, and sometimes even slightly higher than the anterior. However, in some females, the characteristic shape is not very well developed.

		L.	H.	D.
Size:	(Males) 1. Aladdin, Cat. No. 61.3522	177 mm.	70 mm.	49 mm.
	2. Neville Island, Cat. No. 61.706	175 "	70 "	51 "
	3. Industry, Cat. No. 61.4077	100 "	41 "	27 "
	4. Mosgrove, Cat. No. 61.4075	71 "	31 "	16 "
	(Females) 5. Cooks Ferry, Cat. No. 61.3519	156 "	67 "	52 "
	6. Industry, Cat. No. 61.4077	140 "	60 "	38 "
	7. Industry, Cat. No. 61.3518	111 "	47 "	31 "
	8. Meadville, Cat. No. 61.3512	89 "	40 "	23 "
(*Lake Erie-form*)	9. Erie, Cat. No. 61.4070 (♂)	118 "	47 "	33 "
	10. do. " " do. (♀)	112 "	52 "	31 "

The species is said to grow even larger than the largest specimens listed above, but Pennsylvanian specimens compare favorably with specimens from other localities.

Soft parts (See Lefevre & Curtis, 1910, Pl. 1, fig. 5; 1912, Pl. 7, fig. 6; Ortmann, 1912, p. 344, fig. 24). *Glochidia:* Lea, Obs. VI, 1858, Pl. 5, fig. 11; Lefevre & Curtis, 1910, p. 97, fig. L; Ortmann, 1911*b*, Pl. 89, fig. 21; Lefevre & Curtis, 1912, p. 146, fig. L; Surber, 1912, Pl. 2, fig. 17. My measurements are: 0.22 × 0.28; those of Lefevre & Curtis: 0.20 × 0.24; those of Surber: 0.220 × 0.280 mm.

Breeding season: I have the following records of gravid females: Aug. 13, 1907; Aug. 29, 1908; Aug. 30, 1909; Sept. 1, 1908; Sept. 3, 1908; Sept. 5, 1908; Sept. 6, 1908; Sept. 7, 1914; Sept. 8, 1908; Sept. 11, 1913; Sept. 12, 1913; Sept. 14, 1915; Sept. 15, 1909; Sept. 17, 1913; Sept. 17, 1915; Sept. 22, 1910; Sept. 23, 1908; Sept. 24, 1917; Oct. 24, 1907; Oct. 24, 1910; Nov. 4, 1914; Nov. 12, 1911; and then again: May 21, 1909; May 22, 1909; May 23, 1914; May 25, 1914; July 5, 1909; July 10, 1908; July 23, 1907.

Eggs have been found in August (earliest date Aug. 13). In September and October specimens with glochidia are present, and then again in May. But all three records in July refer to specimens with glochidia. Thus the breeding season lasts from about the middle of August to the end of July, and may overlap with the next, or there may be a short interval at the end of July and in the first half of August. Surber found glochidia in September, October, November, in March, April, and May, and then again in July, which agrees well with my records. The species is *bradytictic.*

Remarks: Eurynia recta generally is easily recognized by its large size, elongated shape, and almost black color. However, young male specimens sometimes resemble *Elliptio dilatatus,* but may be distinguished by the shining, green-black epidermis, with indistinct, broad rays (if such are at all visible). *Elliptio dilatatus* has a dull, more brownish-black epidermis, with fine rays (if such are at all visible). The posterior end of *E. recta* is also more pointed, and the nacre is generally not so deeply colored as in *E. dilatatus.* There are additional differences in the hinge-teeth and the beak-sculpture. The female shell of *E. recta* cannot be confounded with *E. dilatatus.*

Eurynia recta is not very variable. The proportion of length and height varies slightly, and so does the color of the epidermis and of the nacre. In Lake Erie there is a local form, which differs from the Ohio type by its smaller size, its paler epidermis (browner, inclinding to russet), and more regular growth-lines. But there are specimens in the lake, chiefly younger ones, which are indistinguish-

able from specimens from the Ohio River. Therefore I do not think it advisable to separate the two forms by varietal names.[182] Specimens from Maumee River are entirely normal, *i.e.*, like the Ohio-form.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Shippingport, Cook's Ferry, and Industry, Beaver Co.; Neville Island, Allegheny Co.; Edgeworth, Allegheny Co. (G. H. Clapp).

Allegheny-drainage: [183]

Allegheny River, Schenley, Aladdin, Godfrey, White Rock (Johnetta), Kelly, Mosgrove, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

Crooked Creek, Rosston, Armstrong Co.

French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Connewango Creek, Russell, Warren Co. (Dr. R. R. Jones).

Monongahela-drainage:

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Dunkard Creek, Wiley, Greene Co.

Cheat River, Cheat Haven, Fayette Co.

Lake-drainage:

Lake Erie, Presque Isle Bay, and beach-pools of Presque Isle, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Severn River, Gloucester Pool, Muskoka Co., Ontario, Canada (O. A. Peterson).

Lake Erie, Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich); Cedar Point, Erie Co., Ohio (C. Brookover); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Maumee River, Waterville, Lucas Co.; and Otsego Rapids, Wood Co., Ohio (C. Goodrich).

Ohio-drainage:

Tuscarawas River, Ohio (Holland collection).

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.

Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

Elk River, Shelton and Clay, Clay Co.; Gassaway, Braxton Co., West Virginia.

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

[182] It should be borne in mind that the original *recta* of Lamarck is from Lake Erie, and was subsequently called *sageri* by Conrad (See Walker, 1913, p. 21). The name *recta* should be retained for the lake-form, while for the form from the Ohio the varietal name *latissima* Rafinesque is available.

[183] In addition it may be stated that dead shells have been seen, but not taken, in the Conemaugh River, New Florence, Westmoreland Co.

Tennessee-drainage:

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Concord and Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Nocton, and Holston Station, Grainger Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

Mississippi-drainage and westward:

Kaskaskia River, Illinois (G. H. Clapp, donor).

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Neosho River, Miami, Ottawa Co., Oklahoma (F. B. Isely).

Alabama-drainage:

Coosa River, Wilsonville, Shelby Co.; Riverside, St. Clair Co., Alabama (H. H. Smith).

Chattooga River, Cedar Bluff, Cherokee Co., Alabama (H. H. Smith).

Distribution and Ecology in Pennsylvania (See fig. 29): *Eurynia recta* is found in Pennsylvania in Lake Erie and in the Ohio-drainage. In the latter it distinctly prefers the larger rivers, where it is generally abundant, and attains a huge size. In the Allegheny it goes up to Warren County. Yet it has also entered some of the smaller tributaries. It is found in the lower part of Crooked Creek, in French Creek (up to Cambridge Springs), and in Connewango Creek. It also must have gone up the Kiskiminetas, for dead shells have been seen in the Conomaugh at New Florence. In the Monongahela-drainage it is present in the lower part of Dunkard Creek, and it is in Cheat River, where it passes up into West Virginia. On the other hand, its total absence in the whole Beaver-drainage is most remarkable.

Its ecological preferences show that it is mainly a form of the big rivers. In the Ohio it belongs chiefly to the shell-banks in the deep channel of the river with

gravelly bottom and strong, steady currents. In smaller streams it is also mostly in very strong currents and in heavy gravel on riffles. It buries very deeply. In Lake Erie it is found in the fine sand and gravel of Presque Isle Bay, in protected locations (among rushes) as well as on open, surf-beaten shores. It is also in some of the beach-pools with quiet water and sandy-muddy bottoms.

General distribution: Type locality, Lake Erie (Lamarck).

The metropolis of *E. recta* is in the large rivers of the central basin. From western Pennsylvania, it spreads all through the Ohio-drainage in Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a*, 1900), in West Virginia, and eastern Kentucky. From the rest of Kentucky records are lacking, but it is in the Cumberland (Marshall, 1895; Wilson & Clark, 1914), and in the Tennessee, where it ascends in the Clinch River to Virginia. It is common in the Mississippi-drainage in Illinois (Baker, 1906), Iowa (Pratt, 1876; Witter, 1878; Call, 1895; Marshall, 1895; Geiser, 1910), and northward to Wisconsin (Conrad, 1836; Cooper, 1855; Lapham, 1860), and Minnesota (Cooper, 1855; Grant, 1886; Holzinger, 1888).

In the Missouri-drainage, it is found in Missouri (Utterback, 1916), in northeastern Kansas (Scammon, 1906), and southeastern Nebraska (Tryon, 1868; Call, 1895). Southward it becomes less abundant, but is known from the southern drainage in Kansas (Scammon), Arkansas (Call, 1895; Marshall, 1895; Wheeler, 1918), and Oklahoma. Its presence in Texas is doubtful.

In addition this species has crossed over into other drainages in the north as well as in the south. From northern Indiana and Ohio it has reached the lake-drainage in Michigan (Walker, 1898) and Lake Erie (Walker, 1913), and has spread down the St. Lawrence far into eastern Canada, Ottawa, Quebec, Montreal (See Bell, 1859; Whiteaves, 1863; Call, 1885; Marshall, 1895) and has entered some of the tributaries of the St. Lawrence in western New York (Marshall, 1895). In Ontario it goes northwest at least to the region of Georgian Bay, Severn River (See Carnegie Museum). Further in Minnesota it has crossed over into the drainage of the Red River of the North, Wilkin County (Grant, 1886), and has reached North Dakota, at Pembina (Call, 1885) and Roseau River (Dawson, 1875), Winnipeg (Christy, 1855; and Hanham, 1899) Canada.

Finally it is found in the south in the Alabama-drainage in Alabama and Georgia (Conrad, 1836; Lewis, 1877; Call, 1885, 1895).

As has been said, it prefers larger rivers, and within the immense area indicated above, it may be missing in many of the smaller, and even medium-sized streams. Baker (1898*a*) records it from lakes and large rivers, on muddy bottoms, while Scammon (1906) says that it is found under a variety of conditions.

Genus Lampsilis Rafinesque (1820).

Ortmann, 1912, p. 345; Simpson, 1914, p. 35.

Type *Unio ovatus* Say.

In Pennsylvania I distinguish seven species and three varieties, which are to be recognized as follows:

Key to the Species and Varieties of Lampsilis.

a_1. Shell subelliptical, elongated, considerably over one-and-a-half times as long as high.

b_1. Shell more or less swollen; in the female greatly inflated and broader behind. Epidermis more or less smooth and shining, with the rays, when present, rather sharply defined.

c_1. Larger, greenish-yellow, with dark rays, colors bright. Growth-lines irregular and not very distinct..... *L. luteola.*

c_2. Smaller, pale yellowish, or pale brownish, rays not so dark, colors duller. Growth-lines generally distinct and regular..... *L. luteola rosacea.*

b_2. Shell more or less compressed, in the female not so greatly inflated and broadened behind. Epidermis rough, and not shining, with the rays less sharply defined..... *L. radiata.*

a_2. Shell suboval or subelliptical, not elongated, rarely about one and a half times as long as high, generally shorter.

b_1. Shell moderately thick, or even comparatively thin. Color of epidermis yellowish, greenish, or grayish olive, or dull brownish. Rays variable, but, when present, generally sharply defined.

c_1. Epidermis yellowish or greenish olive, more or less shining (dull only in old shells). Rays, when present, more or less sharply defined.

d_1. Epidermis more or less greenish, more or less shining; when yellowish, the rays cover most of the shell.

e_1. Rays absent or simple, broader or narrower, not much crowded. Shell rather large.

f_1. Shell larger, colors brighter, rays more sharply marked, when present, and rather dark.

g_1. A sharp posterior ridge present, and posterior slope truncate.... *L. ovata.*

g_2. No sharp posterior ridge, posterior slope not truncate. *L. ovata ventricosa.*

f_2. Shell smaller, colors duller and paler, rays less distinct and not very dark. *L. ovata canadensis.*

e_2. Rays always present, fine, rarely somewhat broad, much crowded, and more or less interrupted or wavy. Shell of smaller size..... *L. fasciola.*

d_2. Epidermis bright yellow (wax-yellow), sometimes inclining to reddish brown, very bright and glossy. Rays, if present, very distinct, but generally restricted to the posterior part of the shell..... *L. cariosa.*

c_2. Epidermis dull in color, grayish olive, not very shining. Rays ill-defined..... *L. ochracea.*

b_2. Shell very thick and heavy. Color of epidermis more or less reddish-yellow or brown. Rays indistinct..... *L. orbiculata.*

Lampsilis luteola (Lamarck) (1819).

Lampsilis luteola (Lamarck) Simpson, 1914, p. 60.

Plate XVII, figs. 1, 2.

Records from Pennsylvania:

Clapp, 1895 (Allegheny Co.)
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.; Beaver, River, Wampum, Lawrence Co.)
Ortmann, 1909*b*, p. 190, 202.

Characters of the shell: Shell from medium size to rather large, moderately thick. Outline subelliptical or subovate, moderately elongated, distinctly over one-and-a-half times as long as high, but less than twice as long as high. Anterior margin rounded. Lower margin more or less regularly curved. Upper margin nearly straight, forming with the posterior margin a blunt angle, when young, or passing gradually into it, when old. Posterior margin meeting the lower margin in a very blunt angle, so that the posterior end of the shell is rather rounded off. Beaks low, located in the anterior portion of the shell. Beak-sculpture (see Marshall, 1890, fig. 3) fine, consisting of six to ten double-looped bars, with a distinct re-entering angle in the middle. The posterior loop is slightly angular, and indistinct upon the posterior slope. Sometimes the first bar appears subconcentric. Valves more or less swollen, rarely subcompressed, but flattened upon the sides. Posterior ridge indistinct.

Epidermis yellowish to light greenish, or light brownish, shining and smooth. In old shells it is darker, but not blackish. Rays are generally present. They are dark green to blackish, quite distinct, straight, narrow or broad, covering more or less of the surface. Posterior slope often darker in color, and less shining. Growth-rests more or less distinct, but irregular.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, tooth-like, compressed or stumpy, crenulated, very variable. Interdentum absent. Lateral teeth long, but rather thin, gently curved. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct and well impressed, chiefly the anterior one. Nacre milky-white, silvery, somewhat iridescent behind.

Sexual differences very strongly marked. While the male shell uniformly tapers backward to the bluntly pointed end, having the lower margin rather evenly curved, the female develops a considerable swelling and expansion of the lower margin in the postbasal region, so that the anterior part of the lower margin is nearly straight (or even slightly concave), and the posterior section of it ascends very suddenly to the posterior end. This produces a considerable widening of the posterior end of the shell, which often appears truncated. In old females this feature is so prominent, that the shell actually seems to be distorted.

		L.	H.	D.
Size:	(Males) 1. Linesville, Cat. No. 61.4027	142 mm.	78 mm.	60 mm.
	2. Jamestown, Cat. No. 61.3453	125 "	69 "	54 "
	3. Rosston, Cat. No. 61.4036	78 "	45 "	23 "
	(Females) 4. Linesville, Cat. No. 61.4027 (gravid)	111 "	73 "	60 "
	5. Wampum, Cat. No. 61.2873	101 "	68 "	41 "
	6. Shenango, Cat. No. 61.4100 (gravid)	71 "	46 "	26 "

The maximum length given by Baker (1898*a*) is 116 mm., by Scammon (1906), 136 mm. Thus it is seen that the Pennsylvanian specimens attain an extreme size.

Soft parts (See Ortmann, 1912, p. 348). *Glochidia* (See Lea, Obs. VI, 1856, Pl. 5, fig. 10; Surber, 1912, Pl. 2, fig. 15). My measurements are: 0.23 × 0.28, while Surber gives: 0.250 × 0.290 mm. But Surber remarks (1912, p. 4) that at certain localities, the glochidia are uniformly smaller than at others.

Breeding season: My dates for gravid females are very numerous, and cover the periods from August 3 to October 27, and from April 22 to July 19. The

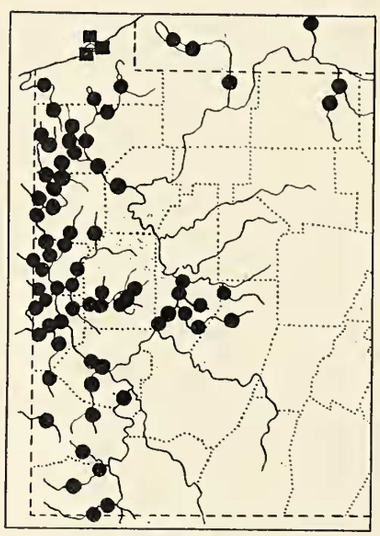


Fig. 30.

● *Lampsilis luteola.*
■ *Do. var. rosacea.*

species is *bradytictic*, but found gravid nearly all the year round, except in July, where there seems to be a short interim. Although gravid (and discharging) females have been found in July, they are rare in this condition in that month.

Remarks: A very variable species, but recognized by its subelongated shape, the light color of the epidermis, which is shining, and has generally well-marked

rays. Young specimens of *Actinonaias ligamentina* sometimes resemble this species, but their shape is more broadly elliptical. Large individuals of *Eurynia iris* also might be mistaken for *L. luteola*, but they have a more elongated shape, more iridescent nacre, and besides the character of the rays is different.

In old specimens the epidermis is often more or less discolored, and the smoothness disappears, but specimens with dark (brown or black) epidermis are very rare. The typical inflation of the valves is best developed in old individuals, while young ones are generally more or less compressed.

Several forms (or species) have been distinguished. The variety *rosacea* will be discussed below. But there are other local forms, which, however, are not constant enough to deserve special mention, and most of them are not found in our state.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River and Ohio-drainage:

Ohio River, Cooks Ferry and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Buffalo Creek, Acheson, Washington Co.

Little Beaver Creek, Cannelton (Miss Vera White & H. H. Smith), Darlington, and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, Raccoon Township, and New Sheffield, Beaver Co.; Bavington, Washington Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson & J. L. Graf).

Little Chartiers Creek, Morganza, Washington Co.

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Zelienople and Harmony, Butler Co.

Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.

Brush Creek, Celia, Beaver Co.

Little Connoquenessing Creek, Harmony, Butler Co.

Glade Run, Zeno, Butler Co.

Thorn Creek, McBride, Butler Co.

Bonnie Brook, East Butler, Butler Co.

Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.

Neshannock Creek, Volant, Lawrence Co.; Leesburg, Mercer Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Little Shenango River, Greenville, Mercer Co.

Randolph Run, Hartstown, Crawford Co.

Padan Creek, Linesville, Crawford Co. (O. E. Jennings).

Allegheny-drainage:

Allegheny River, Johnetta, Kelly, Mosgrove, and Templeton, Armstrong Co.; Larabee, McKean Co. (Dennis Daily).
Crooked Creek, Rosston and South Bend, Armstrong Co.; Creekside, Indiana Co.
Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).
Little Mahoning Creek, Goodville, Indiana Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Conneauttee Creek, Edinboro, Erie Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

Monongahela-drainage:

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson).
Ten Mile Creek, Clarksville, Greene Co.; Amity, Washington Co.
South Fork Ten Mile Creek, Clarksville and Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.

Lake Erie-drainage:

Conneaut Creek, Springboro, Crawford Co.; West Springfield, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Genesee River, Rochester and Chili, Monroe Co., New York (R. H. Santens).
Black Creek, Chili, Monroe Co., New York (R. H. Santens).
Conestogo River, Conestogo, Waterloo Co., Ontario, Canada (Miss Maria Jentsch).
Creek at North Fairfield, Huron Co., Ohio (O. E. Jennings).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Cedar Creek, Jerusalem Township, Lucas Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids, Lucas Co., Ohio (C. Goodrich).
St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).
Blanchard River, Findlay, Hancock Co., Ohio (C. Goodrich).
Silver Creek and Beaver Creek, Williams Co., Ohio (C. Goodrich).
Ten Mile Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Otter Creek, La Salle Township, Monroe Co., Michigan (C. Goodrich).
Raisin River, Adrian, Lenawee Co.; Grape P. O., Monroe Co., Michigan (C. Goodrich).
Long Lake, Fenton, Genesee Co., Michigan (C. Goodrich).

Ohio- and Mississippi-drainage:

Chautauqua Lake, Chautauqua Co., New York.[184]
Mahoning River, Leavittsburgh, Trumbull Co., Ohio (Smith collection).

[184] I have numerous specimens collected by R. Foerster, D. Brown, D. R. Sumstine, P. E. Nordgren, and Miss B. Ortmann, from various localities in the lake. They represent a somewhat *dwarfed* form, which in this respect resembles the var. *rosacea,* but agrees in other respects with typical *luteola.*

West Branch Nimishillen Creek, Canton, Stark Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Wolfe Creek P. O., Washington Co., Ohio (W. F. Graham).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Ohio River, Toronto, Jefferson Co., Ohio.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.[185]
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Mud River, Milton, Cabell Co., West Virginia.
Licking River, Farmer, Rowan Co., Kentucky.[186]
Muscatine Slough, Muscatine, Muscatine Co., Iowa (Hartman collection).
Mississippi River, Moline, Rock Island Co., Illinois (P. E. Nordgren).
Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).

West of Mississippi:

Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Bull Creek, Miami Co., Kansas (C. Goodrich, donor) (Osage-drainage).
Spring River, Williford, Sharp Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).[187]
Fourteen Mile Creek, McBrides Switch, Wagoner Co., Oklahoma (F. B. Isely).[187]

Distribution and Ecology in Pennsylvania (See fig. 30): This is a common species in western Pennsylvania, although not found everywhere. It is averse to large rivers, and, if at all present in them, is either rare, or is found under special conditions, in smaller branches of the main river (as for instance at Neville Island). On the other hand, it is very abundant in some of the smaller streams, as for instance, in the whole Beaver-drainage. It avoids certain streams, and this is especially true of mountain-streams, such as Cheat River and the Kiskiminetas-drainage.[188] It occurs in the only tributary of Lake Erie, in our state, which contains shells (Conneaut Creek).

[185] I have seen this species in Oil Creek, Orlando, Lewis Co., West Virginia.

[186] I have also seen specimens in Fleming Creek, Pleasant Valley, Nicholas Co., Kentucky.

[187] Some specimens from Ouachita River and from Oklahoma are quite typical, but Wheeler (1918, p. 117) does not report *L. luteola* from Clark Co., Arkansas. In this region peculiar forms turn up, some of which develop reddish color in the nacre, and others intergrade in the direction of *L. hydiana* (Lea). I omit these since I have not enough material to clear up their affinities.

[188] The fauna of this system is poorly known. However, remarkably enough, this species has not been listed by Harn (1891), whose material seems to have come chiefly from the Kiskiminetas-Conemaugh-drainage. This serves to substantiate the above conclusion, since I never found this species in the two creeks of this region, where I have been able to collect the fauna (upper Loyalhanna and Quemahoning). Also in Yellow and Two Lick Creeks, where a fragmentary fauna has been observed, this species was not present.

Ecologically this species is found under a number of conditions, but there is no doubt that it prefers rather quiet water and sandy-muddy bottoms. Strong currents and rough bottoms do not suit it, and although occasionally found in riffles, it probably has in such cases been washed out of the quieter pools. In the quiet water below riffles, where there is more or less muddy bottom, or in slowly running water with fine gravel, sand, and mud, it is abundant. This accounts for its absence in mountain-streams, and its absence or scarcity in the large rivers, while its most favorable localities are in the plateau-streams, or the streams within the glacial drift, which are more sluggish and have finer bottom material. For this reason, this species is also much inclined to go into lakes.

General distribution: Type locality, According to Lamarck this species comes from the Susquehanna and Mohawk Rivers. Its presence in the Susquehanna has never been confirmed, but in the Mohawk it has been found subsequently (Lewis, 1860; Marshall, 1895), and also at other places in the Mohawk and Hudson drainages, as well as in the Erie Canal (DeKay, 1843; Simpson, 1891; Marshall). The *Mohawk* should be designated as the type-locality. This is in the Atlantic-drainage, but the chief distribution of this species is in the Interior basin.

In New York it is also known from the St. Lawrence-drainage (Marshall, 1895), and material in the Carnegie Museum from the Genesee system shows that it is the typical *luteola,* which is found there. It is also found in New York in the Ohio-drainage, in Ischua Creek, Cattaraugus Co., and Lake Chautauqua (Marshall). How far the typical form extends northward in this region is unknown. It has been reported from Canada (Ontario, and also westward in the St. Lawrence-drainage up to Lake Superior, and from the Hudson Bay-drainage) but in these northern parts it seems, that its place is largely, if not entirely, taken by certain varieties, chiefly *rosacea* (See below). Yet the typical form is certainly present north of Lake Erie as is shown by specimens in the Carnegie Museum (Conestogo River) (also reported from northern Michigan, in Manistique River, Schoolcraft Co., by Winslow, 1917).

Westwards *L. luteola* is found practically all over western Pennsylvania, Ohio, Indiana, and Illinois, crossing over into the lake-drainage at various points, and it extends northward through Iowa, Wisconsin, and Minnesota into the drainage of the Red River of the North, although, as has been said, it seems in the northern parts of its range to give way to varieties.

Lewis (1877) calls attention to the fact that this species has not been recorded from "any stream much south of the latitude of the Ohio River," but that possibly it is present in Kentucky. Material in the Carnegie Museum shows that it occurs

in West Virginia not only in the headwaters of the Monongahela, but also in the Little Kanawha, in the Kanawha and Guyandotte drainages; but that it is absent here in certain regions, for instance, in the Elk River of the Kanawha system. This no doubt is due to the rough character of Elk River. In addition I found this species in the Licking River in Kentucky. But it actually seems to be absent in the Cumberland and Tennessee River drainages.

In a westward and southwestward direction this species undoubtedly goes as far as Missouri (Utterback, 1916), Kansas (Scammon, 1906), Arkansas, and Oklahoma, and has been reported to exist in Texas (Brazos River, Simpson, 1900). However, in this region it passes into other forms (*hydiana*, for instance) which may, or may not be, "good species." In Mississippi and Alabama it seems to be represented by kindred forms, which are generally considered to be different species.

Thus *L. luteola* has its main range chiefly in the northern section of the Interior Basin, north of the Ohio, and passes into the northern drainages of the St. Lawrence and Hudson Bay. But in the north, as well as in the south, it inclines to variation, and has developed geographical and local races, some of which may be regarded as valid species.

Both Baker (1898*a*) and Scammon (1906) call this a mud-loving species, which agrees with my observations. Although sometimes found in other environment, it thrives best and is most abundant in mud and sluggish or quiet water. This satisfactorily explains its absence in certain streams in western Pennsylvania and West Virginia, and possibly also in the Tennessee-Cumberland-drainage. This also holds good in the Ohio River between Pennsylvania and Cincinnati. I found it in the Ohio at Toronto, in a small branch of the river, but at no other locality, and it was entirely missing in the numerous piles of the clam-diggers examined by myself.

Lampsilis luteola rosacea (DeKay) (1843).

Lampsilis luteola rosacea (DeKay) Simpson, 1914, p. 62; Walker, 1913, p. 21.

Plate XVII, figs. 3, 4, 5.

Record from Pennsylvania:

Ortmann, 1919*b*, p. 202 (as lake-form of *L. luteola*).

Characters of variety: This may be described as a small, stunted form of *L. luteola*, generally with rather light-colored (pale yellow to rusty) epidermis, with white or (locally) rosaceous nacre. The specimens from Lake Erie (and also other lakes) have generally more regular, more crowded, and more distinct growth-rests.

		L.	H.	D.
Size:	(Males) 1. Erie, Cat. No. 61.4858	89 mm.	49 mm.	31 mm.
	2. do. Cat. No. 61.4020	76 "	44 "	27 "
	3. do. Cat. No. 61.4020	51 "	29 "	18 "
	(Females) 4. Erie, Cat. No. 61.4020 (gravid)	81 "	54 "	35 "
	5. do. Cat. No. 61.4020 (gravid)	64 "	41 "	28 "
	6. do. Cat. No. 61.4860	52 "	34 "	20 "

Soft parts identical with those of the main species, *glochidia* also identical.

Breeding season: Gravid females are on record for May 21, 1909; May 22, 1909; May 24, 1909; July 7, 1910; July 12, 1910. All these specimens had glochidia, and on July 7 and 12 a number were observed discharging the glochidia. The variety is certainly *bradytictic*, like the main species.

Remarks: The original description of *rosaceus* DeKay is founded upon specimens with special features: rosy nacre and pallid brown epidermis. But Simpson (1900, p. 535, footnote 1) pointed out that this probably is only a local effect, and that other specimens have white nacre and differently colored (darker) epidermis.[189] I find, that there is in Lake Erie great uniformity in the color of the nacre, which is always white, while there is great variability in the color of the epidermis. Specimens from the surf-beaten shores of the open lake are remarkably light, and the ground color of the epidermis is light yellow or light greenish (grayish-green), while those from protected localities in Presque Isle Bay, and from beach-pools, are more greenish-olive, lighter or darker, and often incline toward a reddish brown, which is most intense and brilliant towards the beaks. In the growth-lines there is great variability, but the tendency is to have them rather closely set, rather distinct and regular. This is most evident in specimens from deeper water, least so in those from the beach-pools.

The characters of this variety are very poorly marked. It is true that specimens from Lake Erie generally are recognizable by size, color, and distinct growth-lines; but in specimens from other localities these characters are more or less unstable, and transitional conditions toward true *luteola* are frequent. I have already mentioned that in *L. luteola* from Lake Chautauqua, which incline toward *rosacea* in size, other characters are normal. Specimens from Winona Lake look much like the Lake Erie form, having the reddish epidermis and very distinct growth-lines, but are larger. Specimens from Moose River are small and pale in color, but the growth-lines are indistinct.

Specimens collected by O. E. Jennings on the North shore of Lake Superior much resemble the Lake Erie form, being pale in color, without rays, but they differ

[189] Utterback (1916, p. 185) relying only on the color of the nacre, erroneously called the red-nacred form of Missouri (also found in Arkansas) by the name of *L. luteola rosaceus*.

in different localities. A specimen from Nipigon Straits is absolutely like the Lake Erie form, while others from Six Mile Lake (a shallow lake on Thundercape Peninsula) have irregular growth-lines, and incline more toward normal *luteola*. These specimens could not very well be called *superiorensis*, for they do not have a dark epidermis. Then again specimens from Kaministiquia River (tributary to Lake Superior at Fort William) are darker in color, and might possibly represent the real *superiorensis*.

Specimens from Sheyenne River, North Dakota, are indistinguishable from certain Lake Erie specimens, except for the irregular growth-lines.

I have the impression that *rosacea* is not so much a geographical, as an ecological race, produced by the environment of great lakes, and that it turns up, whenever the proper conditions are offered. Since this environment is very widely distributed in the northern states and in Canada, *rosacea* appears as a geographical race. In this connection it should be emphasized that this variety is not found in the tributaries of the lakes, but that the normal form of *luteola* exists there. There are also certain lakes, in which the form *rosacea* is not present, for instance Lake Chautauqua, and Conneaut Lake. In the latter *luteola* is quite typical.

More detailed investigations are required to finally determine this question. It also should be ascertained to what factors the rose-colored nacre may be due. Our specimens from Sandy Lake, Ontario, have red nacre, and come from a lake, the water of which is, according to Mr. G. H. Clapp, heavily charged with lime.

Localities in Pennsylvania represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, outer shore, and beach-pools of Presque Isle, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Lake Ontario, Braddock Bay, Manitou Beach, Monroe Co., New York (R. H. Santens).

Lake Erie, Sandusky Bay, Cedar Point, Erie Co., Ohio (C. Brookover) (O. E. Jennings); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Crystal Beach (F. Behrle) and Port Colborn, Welland Co. (C. Goodrich); Port Rowan and Port Dover, Norfolk Co., Ontario, Canada (C. Goodrich).

Sandy Lake, Peterboro Co., Ontario, Canada (G. H. Clapp).

Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).[190]

Winona Lake, Kosciusko Co., Indiana (E. B. Williamson) (not typical).

Lake Wiwassee, Kosciusko Co., Indiana (C. Goodrich).

Lake Huron, Port Huron, St. Clair Co., Michigan (N. M. Grier); Saginaw Bay, Michigan (Smith collection).

Big and Little Whitefish Lakes, Pierson, Montcalm Co., Michigan (Miss M. O'Malley).

Au Sauble Lakes, Lake Co., Michigan (C. Goodrich).

Douglas Lake, Cheboygan Co., Michigan (H. B. Baker).

[190] A small race of *luteola*, and probably var. *rosacea*, although not typical. It should be noted that in the Upper Grand River-drainage (Conestogo River), the real *L. luteola* is present.

Crystal Lake, Benzie Co., Michigan (B. Walker, donor).
Lake Michigan, off Kenosha, Kenosha Co., Wisconsin (P. E. Nordgren).
Lake Superior, Nipigon Straits, St. Ignace Island, Ontario, Canada (O. E. Jennings).
Six Mile Lake, Silver Island, Thundercape Peninsula, Ontario, Canada (O. E. Jennings).
Lake Nipigon, Ombabika Bay, Ontario, Canada (O. E. Jennings).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).
Moose River, South of Moose Factory, Ontario, Canada (W. E. C. Todd).

Distribution and Ecology (See fig. 30): *Type locality*, Seneca Lake, New York (DeKay).

As Simpson says, this race is found in the St. Lawrence area, and is common in the lakes. However, its exact distribution is not very well known, since it often has not been kept apart from the typical form. In addition our records show, that, in northern Indiana, it is also in some lakes belonging to the Ohio (Wabash) drainage.

Walker (1913) has it from Lake Erie, and he was the first to use the name *rosacea* for the lake-form. Sterki (1907*a*) reports it from Lake Erie in Ohio, but he also gives typical *luteola* from this lake. It may be, that he understood by *rosacea* only specimens with red nacre. But I have never seen such from Lake Erie. Walker (1898) reports *borealis* and *superiorensis* from northern Michigan, but not *rosacea*. What I have from Lake Huron and central and northern Michigan, is indistinguishable from the Lake Erie form. This variety certainly also occurs in Lake Michigan and Lake Superior.

A form very close to this is found in Moose River, near Hudson Bay. It also turns up again, although not quite typical, in the drainage of the Red River of the North in North Dakota.

The ecological preference of this form is certainly for the lake environment, and it is best developed in the larger lakes. In Presque Isle Bay in Lake Erie, where it is a common shell, it is found everywhere on the sandy and gravelly shores, in shallow water, and down to a depth of about fifteen feet in sand and mud. It also is found in the beach-pools of Presque Isle, upon sandy-muddy bottom, and is one of the few shells existing in the open lake, being frequently thrown out alive by the surf.

Lampsilis radiata (Gmelin) (1792).

Lampsilis radiata (Gmelin) Simpson, 1914, p. 64.[191]

Plate XVII, figs. 6, 7.

Records from Pennsylvania:

Gabb, 1861 (Schuylkill and Wissahickon, and League Island, Philadelphia).
Bruckhart, 1869 (Lancaster Co.)

[191] The figures given by DeKay (1843, Pl. 19, figs. 237, 238) as of *Unio ochraceus*, have always been taken for *L. ochracea* (Say), even by Simpson (1914, p. 50), but they actually represent *L. radiata*, and

Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Dean, 1891 (West Branch Susquehanna River, Muncy, Lycoming Co.).
Pilsbry, 1894 (Susquehanna River, York Furnace, York Co.).
Schick, 1895 (Delaware River, Philadelphia; Canal at Manayunk).
Ortmann, 1909*b*, p. 204.

Characters of the shell: Shell of about the same size and similar in shape to that of *L. luteola*. Beak-sculpture also similar (Marshall, 1890, fig. 4), but valves much more compressed. Epidermis yellowish, or light or dark green, more rarely inclining to brownish, not smooth, but roughened by close concentric wrinkles. Dark green or blackish rays are generally present, but they are not well-defined, except that in light-colored specimens they are sharper. Concentric bands of lighter and darker color are often present.

Hinge similar to that of *L. luteola*, as well as the rest of the inside of the shell, but the color of the nacre is more variable, sometimes being entirely white, often tinted with pinkish or salmon, and even entirely of these colors.

Sexual differences of the shell much less marked than in *L. luteola*. The female shell has a similar tendency to expand in the postbasal region, but only slightly, and never so distinctly as in *L. luteola*. Some females are even hard to distinguish from males.

	L.	H.	D.
Size: 1. Manayunk, Cat. No. 61.4051 (probably ♂)	93 mm.	53 mm.	27 mm.
2. do. Cat. No. 61.1789 (♀)	88 "	52 "	28 "
3. Tunkhannock, Cat. No. 61.4054 (gravid ♀)	87 "	49 "	29 "
4. Yardley, Cat. No. 61.3473 (probably ♂)	71 "	42 "	21 "
5. Selinsgrove, Cat. No. 61.4868 (♂)	70 "	40 "	23 "
6. South Waverly, Cat. No. 61.4053 (♀)	60 "	34 "	17 "

Soft parts (See Ortmann, 1912, p. 349) figured by Lea (Obs. II, 1838, Pl. 15, figs. 48, 49). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 20). I observed them in a specimen from Severn River, Ontario. They agree with those of *L. luteola:* L. 0.22 to 0.23, H. 0.27 to 0.28 mm.

Breeding season: According to Conner (1907) "all the year round." I have taken a gravid female with eggs on Aug. 22, 1909. This would indicate the beginning of the season. The female with glochidia was collected Aug. 20, 1914. It might be that this represents the end of the breeding season, which thus would overlap with the next one.

are both probably females, which is seen at once by the general outline of the shell. It is remarkable, that this mistake of DeKay has never been discovered, although his error with reference to his *Unio radiatus* (which is *Eurynia iris novi-eboraci*) has been corrected previously. There is no doubt that the confusion within the two species, *radiata* and *ochracea*, is in large part due to these incorrectly named figures of DeKay.

Remarks: The distinctness of this species from *L. luteola* has been much discussed. Some writers (Dean, 1891) hold that it is sharply separated, while others, among them Simpson (1891), admit that there apparently are intergrades.

According to my experience I must say, that I never had in our state any trouble in distinguishing the two species. *L. radiata* is more compressed, lacks the shining epidermis, often has reddish nacre, and the difference between the male and the female shell is considerably less marked than in *L. luteola.*

But I possess a few specimens which indeed are somewhat abnormal. This applies chiefly to some I received from C. H. Conner, and which come from Newton Lake, Camden Co., New Jersey. These are more swollen than the normal form, and in the female the shell is more expanded in the postbasal region, and in shape they thus greatly resemble *L. luteola.* However, even in these specimens the epidermis has the fine wrinkles of *L. radiata,* and is not smooth and shining as it is in *L. luteola.* I think that these specimens represent the reaction of *L. radiata* to the lake-environment.

With respect to shape and principally color, this species appears to be quite variable outside of Pennsylvania, but within this state it is rather uniform. It seems to me that in the northern parts of its range lighter epidermis (yellow to light brown) prevails, while farther south darker tints (dark green to brownish) are the rule. In the extreme south (southern Virginia and North Carolina) this species seems to develop a distinct local race (var. *conspicua* (Lea)).

It should be mentioned, that *L. radiata* to a certain degree resembles *Actinonaias ligamentina* in general shape and color, and the dark green specimens with broad rays distinctly recall the latter species. Such specimens may be recognized by the more elongated shape, thinner shell, and by the rough epidermis. Likewise the presence of pink in the nacre, and the beak-sculpture serve to distinguish them.[192]

Of course, the examination of the soft parts always shows that these two species have no close genetic relationship.

Localities in Pennsylvania represented in the Carnegie Museum:

Delaware River, Yardley, Bucks Co.
Schuylkill Canal, Manayunk, Philadelphia Co.
Susquehanna River, Selinsgrove, Snyder Co.
West Branch Susquehanna River, Williamsport, Lycoming Co. (D. A. Atkinson).
North Branch Susquehanna River, Tunkhannock, Wyoming Co.

[192] A specimen from Grand Rapids, Michigan, in the Carnegie Museum, was labeled *U. radiatus,* and, has indeed, much external resemblance to this. But closer inspection has shown that it is *Actinonaias ligamentina,* having the smooth epidermis and the beak-sculpture of this species.

Chemung River, South Waverly, Bradford Co.

Other localities represented in the Carnegie Museum:

Ottawa, Ontario, Canada (Hartman collection) (marked: " Lea datum ").
St. Lawrence River, Bluff Island, Clayton, Jefferson Co., New York (Miss A. H. Robinson) (H. Kahl); Grindstone Island, Clayton, Jefferson Co., New York (H. Kahl).[193]
Severn River, Gloucester Pool, Muskoka Co., Ontario, Canada (O. A. Peterson).
Spider Bay of Georgian Bay, Sans Souci, Parry Sound, Ontario, Canada (H. Kahl).
Connecticut River (Hartman collection).
Herkimer Co., New York (Smith collection).
Keuka Lake, Yates Co., New York (G. H. Clapp, donor) (Lake Ontario-drainage).
Little Lakes, Herkimer Co., New York (Smith collection).[194]
Newton Lake, Camden Co., New Jersey (C. H. Conner) (See above).
Delaware River, Newbold, Gloucester Co. (C. H. Conner); and Fish House, Camden Co., New Jersey.
Potomac River, Washington, D. C. (G. H. Clapp, donor).

Distribution and Ecology in Pennsylvania (See fig. 31): In Pennsylvania this species is found in the Delaware and Susquehanna drainages, but it is absent in

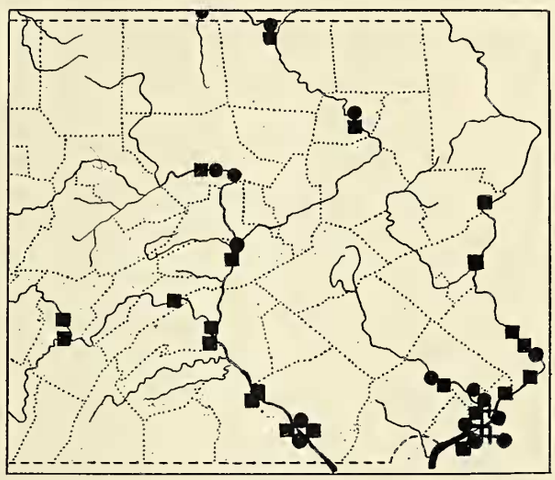


Fig. 31.

● *Lampsilis radiata.*
■ *Lampsilis cariosa.*
+ *Lampsilis ochracea.*

the smaller streams which flow to the Potomac. Altogether it is rare according to my experience, but this may be due to the fact that I did not do much collecting

[193] A dwarf form, with light brown ground-color of epidermis. These specimens might represent *U. borealis* Gray.

[194] This is in Herkimer Co., not in Otsego Co., as given by Lewis (1856, p. 259). These lakes drain into Otsego Lake, and this in turn into the Susquehanna River.

in the tidewaters of the Delaware. According to the older records, its metropolis seems to be in the lower Delaware near Philadelphia. It ascends the larger rivers (Delaware and Schuylkill), but the upper boundary has not been ascertained.

In the Susquehanna-drainage it is distinctly a rare shell. It has been found in the lower part (York Haven, Pilsbry), but otherwise it is restricted to its larger branches. In the West Branch it has been traced up to Williamsport, in the North Branch to the New York state line.[195]

Although present in the lower Potomac, it has never been found in the drainage of this river in Pennsylvania, and it seems to be absent in the whole upper Potomac system West of the Blue Ridge Mountain.

Having found this species only at a few places, and probably not in the most favorable environment, I am unable to say what are the ecological conditions, which it prefers. In the Delaware above Trenton and in the Susquehanna I found it in strongly flowing water in gravel. But here it was unquestionably rare. If its metropolis is in the lower parts of the large rivers, it might be a tidewater species, prefering quiet water, and sandy or muddy bottom. At any rate, I found it on sandy bottom in the lake-like part of the Delaware at Fish House, New Jersey.

General distribution: Type locality, Given by Gmelin from Malabar, which, of course, is incorrect. Lamarck (1819) reports it from Saratoga Lake in New York, and if there should not be any other earlier record, we might select this as the type locality. Simpson (1914) gives Virginia as type locality.

This species belongs to the Atlantic-drainage from Virginia to Maine. In Virginia it is chiefly present according to Conrad (1836) in the tidewaters,[196] and farther South it assumes a different shape, and has been called *conspicua*. Its presence in the lower Potomac in Virginia and the District of Columbia is well established (Dewey, 1856; Marshall, 1895). It is known from the state of Delaware (Rhoads, 1904), Pennsylvania, New Jersey (lower Delaware River, and Second River, Belleville, Essex Co., as *ochraceus* De Kay, 1843), from New York, Connecticut, Rhode Island, Massachusetts and Maine (See Linsley, 1845; Perkins, 1869; Gould-Binney, 1870; Carpenter, 1890; Lermond, 1909; Johnson, 1915). In New York (Marshall, 1895) it ascends the Atlantic rivers (Upper Susquehanna and Hudson) reaching the Mohawk, and crossing over into the St. Lawrence-drainage, where it is found in Lake Ontario and its tributaries, and down the

[195] It goes farther up in New York state, since it occurs in Little Lakes and Schuyler's Lake in the region of the headwaters, and has been reported from Chenango and Tioga Rivers.

[196] It is positively absent in the mountains west of the Blue Ridge, and also seems to be absent or rare on the Piedmont Plateau.

St. Lawrence to Ottawa and Montreal (Bell, 1859; Simpson, 1891; Marshall, 1895).

Possibly it extends its range westward from the lower St. Lawrence, for it has been reported from Lake Nipissing (Bell, 1859), and even farther West, from Lake Superior, Lake Winnipeg, and Nelson River, but these latter localities require confirmation, and a few additional records from Ohio and Indiana are certainly wrong. Its presence in Michigan is doubtful (Walker, 1898). But it is positively present in the region of Georgian Bay: specimens in the Carnegie Museum are nearly normal, except that the color is often more brownish.

This is an Atlantic species, belonging to the northern element in the Atlantic fauna (Ortmann, 1913*a*). In New York it has crossed over into the lower St. Lawrence-drainage, and apparently has here a tendency to spread westward along a route, which lies North of Lake Erie. If this should prove to be correct, attention should be called to the similarity of this range with that of *Elliptio violaceus*.

In New York its range in part overlaps that of *L. luteola* (certainly in the Mohawk and St. Lawrence drainages), but particulars as to the mutual relation and possible association of these two species are lacking. This is a question which requires closer investigation.

As far as known, this species prefers tidewaters, but ascends some of the larger rivers to a considerable distance (Hudson, Susquehanna). Nevertheless in the south it apparently does not have this tendency. The fact that it often goes into canals and is frequently found in lakes, also indicates that rough water and rough bottom (riffles) are not very favorable to it.

Lampsilis ovata (Say) (1817).[197]

Lampsilis ovatus Simpson, 1914, p. 48.

Plate XVII, figs. 8, 9; Plate XVIII, figs. 1, 2, 3.

Records from Pennsylvania:

Call, 1885 (Allegheny River, up to central New York).

Clapp, 1895 (Allegheny Co.).

Marshall, 1895 (Allegheny River, Warren, Warren Co.).

Rhoads, 1899 (confused with *L. ovata ventricosa*, but specimens from Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co., belong here).

Ortmann, 1909*b*, p. 189.

Characters of the shell: For reasons given below, it is best to describe this form in terms of comparison with its variety, *L. ovata ventricosa* (See remarks).

[197] Not 1816.

Similar to *L. ovata ventricosa*, but distinguished by the development of the posterior ridge, which is very sharp and very distinct toward the beaks. In consequence of this the posterior slope is flattened, and in most cases even concave, chiefly towards the beaks. Further towards the anterior end of the shell the two valves are not uniformly convex, but peculiarly compressed, rendering the horizontal cross-section of this part wedge-shaped.

In addition there is a tendency toward the suppression of the rays. Rays are indeed sometimes present, but in most cases the epidermis is uniformly greenish yellow, dark upon the posterior slope and without rays. Old males become drawn out at the posterior end, almost rostrate.

		L.	H.	D.
Size:	(Males) 1. Aladdin, Cat. No. 61.3426	136 mm.	92 mm.	57 mm.
	2. Walnut Bend, Cat. No. 61.3423	103 "	72 "	46 "
	3. Godfrey, Cat. No. 61.4009	86 "	61 "	37 "
	(Females) 4. Industry, Cat. No. 61.3425	126 "	94 "	64 "
	5. Cambridge Springs, Cat. No. 61.4010 (gravid)	100 "	81 "	48 "
	6. Cochranton, Cat. No. 61.3420	83 "	64 "	39 "

Soft parts (See Ortmann, 1912, p. 350, fig. 26). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 15). I have found them to measure: 0.24 × 0.28 mm.

Breeding season: My records for gravid females cover the period from August 4 to October 24, and from May 23 to May 25. The spring records are scanty, but the species is surely *bradytictic*, and there is an interim at least in July.

Remarks: There are numerous intergrades between *L. ovata* and *L. ventricosa*. In the larger rivers, the two forms are practically always associated, and the transition from a very sharp to an almost entirely effaced posterior ridge with the corresponding intermediate condition of the posterior slope, is frequently found. Likewise the other characters given above pass into each other. In color there is also great variability, and, although the true *ovata* has generally no rays, rays are sometimes very well-developed; on the other hand in true *ventricosa* the rays may be lacking. I have quite a number of specimens, which are so completely intermediate, that I am unable to assign them to either form.

Going up beyond a certain point in our rivers, and into the smaller tributaries, *L. ovata* disappears, and its place is entirely taken by *L. ovata ventricosa*, and there are many creeks, where only the form *ventricosa* exists with no trace of *ovata*, and no indications of an inclination toward it.

Exactly the same conditions prevail in the upper Tennessee-drainage in eastern Tennessee and southwestern Virginia, and a form corresponding to *L. ovata ventricosa* develops out of the true *L. ovata* in the headwaters. However, the

Tennessee *ventricosa* has some peculiarities of its own. These shells will be treated elsewhere.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Industry, Beaver Co.; Coraopolis (S. N. Rhoads), Neville Island, and Edgeworth, Allegheny Co. (G. H. Clapp).

Allegheny River, Braeburn, Westmoreland Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

French Creek, Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Conneaut Outlet, Conneautlake, Crawford Co.

Other localities represented in the Carnegie Museum:

Ohio-drainage:

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio.

Elk River, Shelton and Clay, Clay Co., West Virginia.

Tennessee-drainage:

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock and Princeton, Jackson Co., Alabama (H. H. Smith).

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Holston Station, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

Distribution and Ecology in Pennsylvania (See fig. 32): This species is abundant in the Ohio below Pittsburgh, and in the Allegheny all the way up to Warren County. According to Call (1885) it passes by this route into New York, but Marshall (1895) does not report it from the uppermost Allegheny and it has not been found in McKean County, Pennsylvania. From the Allegheny it enters French Creek and extends up to Cambridge Springs. It also enters Conneaut Outlet (but only one dead shell was found there). It is found in no other stream, and its absence is especially noticeable from the whole Beaver-drainage, where *L. ovata ventricosa* on the other hand is common.

No records from the Monongahela are known. However, it is probable that it once existed in the Monongahela proper, at least as far as to the West Virginia state line, for I was able to identify it among the shells from an Indian garbage heap at Point Marion (Ortmann, 1909*c*). It is not found in the upper Monongahela-drainage in West Virginia, where *L. ovata ventricosa* is locally abundant.

Thus *L. ovata* is clearly a form prefering larger rivers, and, according to my

observations, it inhabits in these the roughest parts, riffles with strong currents, the bottoms consisting of large stones, loosely piled over each other, with little finer material packing them together. Of course, occasionally it is found also in finer gravel. I have no doubt, that its chief characters are reactions to the conditions prevailing in riffles. The flattened or concave, truncate posterior slope is

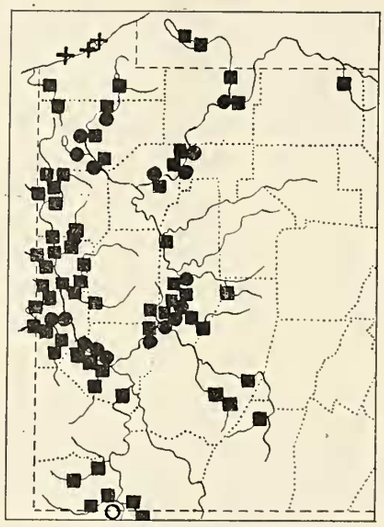


Fig. 32.

● *Lampsilis ovata.* ○ Indian garbage heap.
■ *Lampsilis ovata ventricosa.*
\+ *Lampsilis ovata canadensis.*

produced by the current and the material rolled by it over the posterior end of the shell, when it is imbedded in the gravel; and the wedge-like attenuation of the anterior end is a device to enable the shell to plough through the heavy gravel in which it lives. I have seen the shell moving along in coarse gravel, and pushing aside stones, which were much larger than itself.

General distribution: Type locality, Ohio (Say).

It seems that the Ohio River, the Cumberland, and the Tennessee represent the metropolis of this species. Aside from western Pennsylvania, it is found in the Ohio proper in West Virginia (Carnegie Museum), Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a* and 1900), and Illinois (Baker, 1906). It occurs in very few of the tributaries. Hildreth (1828) gives it from the Muskingum River at Marietta, Washington Co., Ohio; Sterki (1907*a*) from the Great Miami River; and Call from the Wabash, White, and Eel Rivers. In addition, I have found it in Elk River in West Virginia, but only as far up as Clay County. Above this point, its place is taken by *ventricosa*, and the mutual relations of these two forms are

exactly as elsewhere. In the Cumberland, it goes up to the falls (and a little beyond), according to Wilson & Clark (1914); and it has been reported from the Tennessee River as far up as the Holston (Lewis, 1871; Call, 1885), and here it reaches southwestern Virginia, as I have ascertained, in the Clinch River.

The distribution is thus rather restricted, being confined to the larger rivers of the Ohio system. Outside of Pennsylvania I found this species in the rough parts of rivers. In the Ohio below Pittsburgh, where there is more steady current and finer bottom material, it is by no means so abundant as in the Allegheny, for instance. The clam-diggers on the Ohio take it regularly, but not in great numbers.

I have treated as spurious a few records of this species from the lower St. Lawrence in Canada and the Maumee River.

Lampsilis ovata ventricosa (Barnes) (1823).

Lampsilis ventricosa (Barnes) Simpson, 1914, p. 38.[198]

Plate XVIII, fig. 4; Plate XIX, figs. 1, 2, 3.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania) (as *U. occidens* and *U. subovatus*).
Stupakoff, 1894 (Allegheny Co.) (as *U. cariosus*).
Marshall, 1895 (Allegheny River, Warren Co.) (as *U. occidens*).
Rhoads, 1899 (specimens from Ohio River, Coraopolis, Allegheny Co., and from Beaver River, Wampum, Lawrence Co., recorded as *U. ovatus*, belong here).
Ortmann, 1909*b*, p. 182, 202.

Characters of the shell: Shell large, often very large, rather thin when young, but attaining considerable thickness when old. Outline subelliptical or subovate, rather short and high, hardly ever one-and-a-half times as long as high, mostly much shorter. Anterior margin rounded. Lower margin curved. Upper margin short, nearly straight, passing in a blunt angle or gentle curve into the obliquely descending posterior margin. Posterior and lower margins meeting in a blunt, rounded posterior point. Beaks more or less swollen, moderately elevated, located anterior to the middle of the shell. Beak-sculpture consisting of four or five rather coarse bars, of which the second and third have a slight tendency to fall into two loops, with a light sinus in the middle, while the first is indistinct, and the fourth

[198] According to Vanatta (1915, p. 551), *Lampsilis cardium* Rafinesque (1820) is this. I do not accept this identification, since the original description of Rafinesque clearly shows that *L. cardium* is the female of *L. ovata* (Say).

The figures of *Unio cariosus* given by DeKay (1843, Pl. 21, figs. 243, 244), quoted also by Simpson (1914, p. 44) under *L. cariosa*, are undoubtedly *L. ovata ventricosa*, and not *cariosa*.

and fifth tend to become obsolete. All the bars are effaced on the posterior slope. Valves more or less regularly convex, more flattened upon the sides. Posterior ridge poorly developed, mostly quite obsolete, and indicated only by a stronger convexity of the surface, but sometimes this ridge may become more distinct, chiefly so toward the beaks. Posterior slope gently convex or almost flat, but not concave.

Epidermis varying from lighter or darker yellowish green, to olive-brown; smooth and shining. Rays rarely absent, mostly present, but extremely variable. They are dark green to blackish, straight and continuous, finer or broader, and may cover the whole surface or only part of it. On the posterior slope the epidermis is less smooth, and generally darker. Concentric bands may be present.

Hinge well developed. Pseudocardinals generally two in each valve, but extremely variable in shape and size. In young specimens they are more or less compressed; in older ones, more stumpy and ragged. Interdentum absent or narrow. Laterals lamellar, high and strong, that of the right valve generally very broad and suddenly truncated posteriorly. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct, rather well-impressed, chiefly so the anterior ones. Nacre silvery or bluish white, often with a pink blush, or more or less suffused with pink or purplish, but never entirely red.

Sexual differences of the shell well-marked. In the male, the lower margin is rather regularly curved, and the shell has a blunt posterior point. In the female the lower margin is considerably expanded in the postbasal region, the anterior portion thus becoming almost straight, while the posterior ascends suddenly to the blunt posterior end of the shell. The whole posterior section of the shell is much higher than in the male, more expanded, and broadly rounded.

		L.	H.	D.
Size:	(Males) 1. New Galilee, Cat. No. 61.2143	155 mm.	120 mm.	76 mm.
	2. Meadville, Cat. No. 61.3392	115 "	74 "	43 "
	3. Cannelton, Cat. No. 61.2881	76 "	52 "	32 "
	(Females) 4. Neville Island, Cat. No. 61.1582	123 "	88 "	56 "
	5. New Galilee, Cat. No. 61.3236 (gravid)	97 "	71 "	46 "
	6. Darlington, Cat. No. 61.2918 (gravid)	89 "	64 "	40 "

Soft parts (See Ortmann, 1912, p. 35) figured by Lea (Obs. VII, 1860, Pl. 30, fig. 107; Ortmann, 1911*b*, pp. 319, 320, figs. 7, 8). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 13; Ortmann, 1911*b*, Pl. 89, fig. 23; Surber, 1912, Pl. 2, fig. 24). My measurements are: 0.25 × 0.29 mm.; while Surber gives: 0.205 × 0.255 mm. This is a rather unusual discrepancy.

Breeding season: I have a very complete series of dates for gravid females,

from July 30 to October 24, and from May 9 to July 8. The form is *bradytictic*, two succeeding breeding season approaching each other closely in July, but an interim is apparently present in this month. However, an occasional overlapping of the seasons is not impossible. Surber's notes (1912, p. 7) on the presence of glochidia are fragmentary, but they also indicate a possible overlapping of the seasons.

Remarks: The taxonomic relation of this form to *L. ovata* has been discussed above. Both are forms of the same species connected by numerous intergrades, but locally they may be pure. The true *ventricosa* is easily recognized by size, shape, and color. It differs from the allied *L. fasciola* in size, and in the character of the rays (not interrupted or wavy). From the eastern representatives, *L. cariosa* and *L. ochracea* it differs chiefly in size and color. *L. orbiculata* has a much heavier shell and different color.

L. ovata ventricosa is very variable in thickness, shape, and color. There is more or less tendency to form local races. In some creeks it attains giant proportions, while in others it has only a medium size. The latter is the case in the mountain-streams (Cheat, upper Loyalhanna, Quemahoning).

The typical characters, most of all the color, are best developed in shells of medium size. In the upper Ohio greenish is the prevailing tint of the epidermis, which is also glossy; though in old shells the epidermis frequently is discolored and loses its gloss, such shells appearing dull brownish or even blackish. On the average the greenish epidermis and the dark rays give to the shell a comparatively dark aspect, but specimens with light yellowish green or light brownish epidermis, and without rays, are not infrequent. If the nacre is strongly tinted with pink, this color sometimes influences the outer color in young specimens, which appear, reddish brown. A peculiar local race has developed in Lake Erie, and will be discussed below.

With regard to the convexity of the valves and the inflation of the beaks, the Pennsylvanian form varies a little, but not so much as in the southern and western sections of its range. In the South, it is represented by a form with much inflated beaks (*satura* Lea) which also often has a very dark blackish epidermis.

Localities in Pennsylvania represented in the Carnegie Museum:

The Ohio and its smaller tributaries:

Ohio River, Smith's Ferry, Cook's Ferry, Shippingport, and Industry, Beaver Co.; Coraopolis (S. N. Rhoads), Neville Island, and Edgeworth (G. H. Clapp), Allegheny Co.

Little Beaver Creek, Cannelton (Miss Vera White; H. H. Smith), Darlington, and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, New Sheffield, Beaver Co.
Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson).

Beaver-drainage:

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith); Harmony, Butler Co.
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Mahoning River, Mahoningtown and Hillsville, Lawrence Co.
Neshannock Creek, Eastbrook, and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.

Allegheny-drainage:

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Johnetta, Kelly, Mosgrove, Templeton, and Parkers Landing, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co. (Dennis Dally).
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Quemahoning Creek, Stanton's Mill, Somerset Co.
Crooked Creek, Rosston and South Bend, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
French Creek, Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.

Monongahela-drainage:

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson).
Tenmile Creek, Clarksville, Greene Co.
South Fork of Tenmile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

Lake Erie-drainage:

Conneaut Creek, West Springfield, Erie Co.; Springboro, Crawford Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Chagrin River, Cuyahoga Co., Ohio (Hartman collection).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids, Lucas Co.; Defiance, Defiance Co., Ohio (C. Goodrich).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Raisin River, Adrian and Tecumseh, Lenawee Co., Michigan (C. Goodrich).

Ohio-drainage:

Lake Chautauqua, Chautauqua Co., New York (D. R. Sumstine; P. E. Nordgren; Miss B. Ortmann).
Tuscarawas River, Ohio (Holland collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Wabash River, Bluffton, Wells Co., Indiana (C. Goodrich).
Ohio River, Toronto, Jefferson Co., Ohio; Portland, Meigs Co., Ohio.
Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co.; Harrisville, Ritchie Co. (W. F. Graham), West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Little Coal River, Logan Co., West Virginia (Hartman collection).
Mud River, Milton, Cabell Co., WestVirginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

Tennessee-drainage:

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Fayetteville, Lincoln Co., and Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Rock River, Trenton, Jackson Co., Alabama (H. H. Smith).
Little River, Melrose, Blount Co., Tennessee.
Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.
Little Pigeon River, Sevierville, Sevier Co., Tennessee.
Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.
Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.
Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.
Emory River, Harriman, Roane Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

Mississippi-drainage and westward:

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).

Black River (H. E. Wheeler), and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.
Illinois River, Tahlequah, Cherokee Co., Oklahoma (F. B. Isely).
Fourteen Mile Creek, Fort Gibson, Muskogee Co., Oklahoma (F. B. Isely).

Distribution and Ecology in Pennsylvania (See fig. 32): This is a very common form in western Pennsylvania, and is practically found everywhere, both in large rivers and in small creeks. It is often associated with the typical *L. ovata*, in the large rivers, but is distinctly less abundant in these, and, as has been said, intergrades with *L. ovata*. In the smaller streams where typical *ovata* is missing it is extremely abundant, and becomes at favorable localities the prevailing species. It goes far up into the headwaters, eastward to McKean, Indiana, Westmoreland, and Somerset Counties. It should be noted, that it is also found in Conneaut Creek in the Lake Erie-drainage.

In its ecological preferences this form differs decidedly from the normal *L. ovata*, for it does not favor rough bottoms and currents, but rather quiet pools and eddies above and below riffles. Open pools in riffles, in *Dianthera*-patches, with moderate current, and a bottom of fine gravel covered with a thin layer of mud, seem to be most favorable habitats, and occasionally this form is found even in pure sand and rather deep and soft mud. It is the variety of smaller streams, where it is found in rather protected locations, while *L. ovata* is the variety of the rough waters of larger streams.

General distribution: Type locality, Wisconsin River (Barnes).

L. ovata ventricosa is found all over the Ohio and upper Mississippi drainages in western Pennsylvania, West Virginia, Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a* & 1900), Illinois (Baker, 1906; Forbes & Richardson, 1913), Iowa (Pratt, 1876; Witter, 1878; Geiser, 1910), Wisconsin (Barnes, 1823; Cooper, 1855), and Minnesota (Cooper, 1855; Grant, 1886; Holzinger, 1888). It also largely crosses over into the lake-drainage in northern Illinois, Indiana, and Ohio, and occurs in Michigan (Walker, 1898). In New York, it is found in the upper Allegheny-drainage (Chautauqua Lake), and at many places in the St. Lawrence-drainage (Marshall, 1895). That the normal form is found here is shown by specimens from the Genesee River in the Carnegie Museum. In addition it has been reported from the lower St. Lawrence system and its lakes (Erie and Ontario); but in this region it is generally supplanted by the var. *canadensis* (See below), and since this has not been separated from *ventricosa* by most previous authors, the mutual geographical relation of these two forms is obscure. No localities from the Atlantic drainage in central New York are known, and it is missing on the Atlantic slope, with the exception of the upper Potomac River, where it has been introduced

artificially and accidentally in recent times (see Ortmann, Nautilus 26, 1912, p. 51, and 1913*a*, p. 318, and Marshall, Nautilus 31, 1917, p. 40). On the other hand, *L. ovata ventricosa* is reported to cross over, in the northwest, into the Red River and Nelson River systems in Canada, but little is known about the form of this region (See below, under *canadensis*).

In a southerly direction, records from Kentucky are scarce, and Wilson & Clark (1914) report it only from two tributaries of the Cumberland (Harpeth & Stones R.) in Tennessee. But it certainly is found in the upper Tennessee-drainage, where it has a similar relation to *L. ovata* as elsewhere, being preëminently found in smaller streams and in the headwaters.

Westward it goes through Missouri (Utterback, 1916) to southeastern Nebraska (Tryon, 1868; Call, 1885) and eastern Kansas (Scammon, 1906), and southwestward, it is found in Arkansas and Oklahoma. But in this region it passes into the southwestern race called *satura* Lea (Scammon, 1906). In the Alabama-drainage it is represented by allied forms, which require closer investigation.

Baker (1898) and Scammon (1906) say that it is generally found on muddy bottoms, and with some qualification this agrees with my observations in Pennsylvania.

Lampsilis ovata canadensis (Lea) (1857).

Lampsilis ventricosa canadensis (Lea) Walker, 1913, p. 21; *Lampsilis ventricosa lurida* Simpson, 1914, p. 41.

Plate XIX, figs. 4, 5.

Records from Pennsylvania:

Ortmann, 1909*b*, p. 202 (as the lake-form of *ventricosa*).

Characters of the variety: This form differs from *L. ovata ventricosa*, of which it is a local race, by its smaller size, and very light-colored epidermis, which is light-yellow, or light grayish or greenish yellow, with or without greenish rays. In some specimens, the color of the epidermis inclines toward reddish brown or chestnut, chiefly so near the beaks.

In other respects this form agrees with *L. ovata ventricosa*, but old specimens of the male sex are often more elongated than the average *ventricosa* (slightly over one-and-one-half times as long as high).

		L.	H.	D.
Size:	(Males) 1. Erie, Cat. No. 61.3989	101 mm.	66 mm.	46 mm.
	2. do. " " 61.3982	93 "	60 "	42 "
	3. do. " " 61.4883	68 "	46 "	33 "
	(Females) 4. Erie, Cat. No. 61.3982 (gravid)	97 "	68 "	45 "
	5. do. " " 61.4884	83 "	63 "	40 "
	6. do. " " 61.4882	72 "	54 "	40 "

Soft parts identical with those of *L. ovata* and *L. ovata ventricosa*. *Glochidia* not observed.

Breeding season: Gravid females have been seen only on May 21 and 22, 1909. Most of my specimens were collected in the month of July, and no gravid females were among them. Thus the interim seems to be in this month.

Remarks: Simpson (1914) calls this form var. *lurida* (of *ventricosa*), and believes that *U. canadensis* Lea is a synonym of *ventricosa*. However, I follow Walker (1913) in considering the lake-form to be *L. canadensis*.

This form has the same relation to *L. ovata ventricosa*, as has *L. luteola rosacea* to *L. luteola*. It is a small, stunted, light-colored lake-form, which under certain conditions shows the same tendency to become brownish near the beaks. The shell is very variable in color. Specimens from the surf-beaten beaches are very light in color, pale yellow; while those from protected locations in Presque Isle Bay are darker, and tend to have more or less chestnut color toward the beaks. The rays also vary greatly, and often are entirely absent.

Old shells frequently show a peculiar variation in shape, not found in *L. ovata ventricosa*, having a tendency to become more elongated. In this form the growth-rests are also often more regular and more distinct than in *ventricosa*, but this is not always the case. This character is best exhibited in specimens from deep water, and less so in specimens from the surf. The specimens from Ottawa River do not show this. They are also darker grayish green than the average specimens from Lake Erie.

Localities in Pennsylvania represented in the Carnegie Museum:

Lake Erie, Presque Isle Bay, and outer beach of Presque Isle, Erie; beach at Miles Grove, Erie Co.

Other localities represented in the Carnegie Museum:

Ottawa River, Ontario, Canada (B. Walker, donor).

Lake Erie, Vermilion, (C. Goodrich), and Cedar Point, Erie Co., Ohio (C. Brookover; O. E. Jennings); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Port Rowan and Port Dover, Norfolk Co., and Port Colborne, Welland Co., Ontario, Canada (C. Goodrich).

Lake Huron, Saginaw Bay, Charity Island, Michigan (C. Goodrich).

Distribution and Ecology (See fig. 32): *Type locality*, St. Lawrence River, Montreal, Canada (Lea).

Besides the St. Lawrence, this form is found in Ottawa River, and very likely at other localities in the lower St. Lawrence basin and Lake Ontario, generally credited to *L. ventricosa* (Marshall, 1895; Whiteaves, 1863; Bell, 1859). It is

common in Lake Erie (Walker, 1913), and is also in Lake Huron. Whether it extends farther west, remains to be seen.[199]

In the Lake Erie region *L. ovata canadensis* is restricted to the lake proper, and does not go into the tributaries. In the lake this form is found in protected bays as well as in the open lake, and it is one of the few species, which are found in the surf, where I repeatedly picked up living specimens thrown out by the waves. In Presque Isle Bay it is common everywhere, among rushes, and on open shores, going down to a depth of about fifteen feet. It is here mostly on sandy bottom. I never found it in the beach-pools.

Lampsilis fasciola Rafinesque (1820).

Lampsilis multiradiata (Lea) Simpson, 1914, p. 55.[200]

Plate XX, figs. 1, 2.

Records from Pennsylvania:

Harn, 1891 (western Pennsylvania).
Marshall, 1895 (Allegheny River, Warren Co.)
Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.)
Ortmann, 1909*b*, p. 189.

Characters of the shell: The species is best described in terms of comparison with *L. ovata ventricosa*. It is much smaller, and relatively a little thicker. It has a more regularly ovate or elliptical outline. The posterior ridge is quite indistinct. But the chief difference is in the color-pattern of the epidermis. This is yellowish or greenish, or light brownish olive, with very numerous and crowded rays. The latter may be rather broad, or they may consist of bundles of fine (capillary) rays, and they are more or less wavy or interrupted. There are always many fine rays between the wider ones, and often only fine rays are present. The interrupted and wavy character is especially noticeable in the posterior part of the shell. Generally the rays are distinct, but sometimes they are indistinct in the anterior part of the shell. I have never seen a shell in which rays were entirely absent. According to my experience, the nacre is always white.

[199] I have two specimens (male and female) of a form of *ventricosa* from Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards), which represent a depauperate form, but differ from *L. canadensis* by the more elongated shape and the more compressed valves. The material is too insufficient to permit the expression of an opinion. *L. ventricosa* has been reported from the Red River of the North and from Nelson River, but little is known about these forms.

[200] According to Vanatta (1915, p. 552), *Lampsilis fasciola* of Rafinesque is *L. luteola* (Lamarck). Nevertheless in this case I do not accept the determination of the so-called (but *questionable*) "type," since Rafinesque's description is unmistakable, and refers to an ovate (not elongate) shell, with wavy, unequal rays. This fits only the present species.

The sexual differences agree with those of *L. ovata ventricosa*.

			L.	H.	D.
Size:	(Males)	1. Shenango, Cat. No. 61.4099	88 mm.	58 mm.	39 mm.
		2. do. " " do.	62 "	42 "	29 "
		3. do. " " do.	44 "	29 "	18 "
	(Females)	4. Russell, Cat. No. 61.3433 (gravid)	72 "	53 "	35 "
		5. New Galilee, Cat. No. 61.3240 (gravid)	67 "	51 "	34 "
		6. Wurtemberg, Cat. No. 61.4890 (gravid)	47 "	36 "	18 "

The largest male listed above is the largest individual I have ever seen.

Soft parts (See Ortmann, 1912, p. 352). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 17; Ortmann, *l. c.*; Surber, 1915, p. 1, Pl. 1, fig. 2). Surber gives the following dimensions: 0.230 × 0.290 mm.; while I gave: 0.25 × 0.29 mm.

Breeding season: The dates for gravid females are rather complete, extending from Aug. 4 to Oct. 23, and from May 14 to Aug. 9 (the last date furnished discharging specimens). Thus we would have the seasons overlapping early in August. The species is clearly bradytictic. (Discharge has been repeatedly observed in July.)

Remarks: This species is easily recognized and distinguished from *L. ovata ventricosa* by its small size, regular outline, and the character of the rays. I never

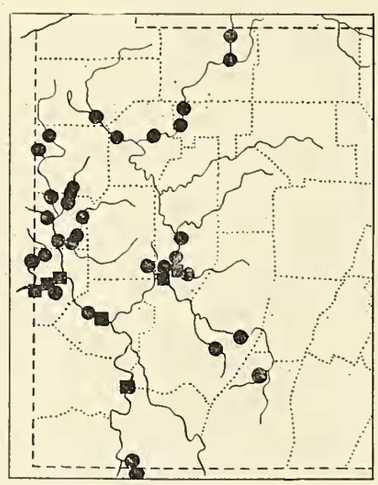


Fig. 33.

● *Lampsilis fasciola.*
■ *Lampsilis orbiculata.*

had any trouble in identifying it, and I have never seen any tendency to intergrade with *ventricosa*, and consider it a well-marked species.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Industry, Beaver Co.
Little Beaver Creek, Cannelton (H. H. Smith), Darlington, and New Galilee, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. L. Simpson, Jr.).
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Mahoning River, Mahoningtown, Lawrence Co.
Neshannock Creek, Eastbrook, and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Pulaski, Lawrence Co.; Shenango, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark, Westmoreland Co.
Quemahoning Creek, Stanton Mill, Somerset Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton, Crawford Co.
Connewango Creek, Russell, Warren Co.
Cheat River, Cheat Haven, Fayette Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Tecumseh, Lenawee Co., and Grape P. O., Monroe Co., Michigan (C. Goodrich).

Ohio-drainage:

White River, Rockford, Jackson Co., Indiana (G. H. Clapp, donor).
Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsvill, Braxton Co., West Virginia.
Elk River, Shelton, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.

Tennessee-drainage:

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Blue Water Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Flint River, Maysville and Gurley, Madison Co., Alabama (H. H. Smith).
Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Rock River, Paint Rock, Trenton, and Princeton, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Little River, Melrose, Blount Co., Tennessee.

Little Pigeon River, Sevierville, Sevier Co., Tennessee.

Pigeon River, Canton, Haywood Co., North Carolina.

Holston River, McMillan and Mascot, Knox Co.; Turley Mill and Holston Station, Grainger Co., Tennessee.

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee; Barron, Washington Co., Virginia.

Watauga River, Watauga, Carter Co., Tennessee.

Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.

Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.

Clinch River, Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

Distribution and Ecology in Pennsylvania (See fig. 33): This species has about the same distribution in western Pennsylvania as *L. ovata ventricosa*, but it is missing in the Lake Erie-drainage. In the Ohio-drainage it is practically generally distributed, but is quite scarce, and never found in great numbers. In the Ohio below Pittsburgh I found it only once, and also in the Allegheny River in Armstrong County. Although found at a number of localities, it is rare. Farther up in the Allegheny and its tributaries it is met with regularly. It is possibly most abundant in Little Beaver Creek, and in the drainage of Beaver River. In the whole Monongahela-drainage it has been found only in the Cheat River, and more abundantly in West Virginia. It is to be noted that it goes up in the Conemaugh-drainage into the mountain-streams in Westmoreland and Somerset Counties.

In Pennsylvania it distinctly prefers riffles with lively currents and gravelly bottoms, but it is not found in very strong currents and among large rocks. The most favorable localities seem to be riffles with an abundant growth of *Dianthera americana* and other water weeds. It distinctly differs in its ecology from *L. ovata ventricosa*, although often found in close proximity to it. But while the latter prefers more quiet water above and below the riffles, *L. fasciola* is found *in* the riffles.

General distribution: Type locality, Kentucky River (Rafinesque).

According to Simpson (1900) it is found in the entire Ohio-drainage; in southern Michigan and in New York. This is essentially correct. In the Ohio-drainage it is practically everywhere, in western Pennsylvania, West Virginia, in Ohio (Sterki, 1907*a*), and Indiana (Call, 1896*a*, 1900). In Illinois it seems to be

less widely distributed, but has been reported from the southern as well as the northern parts of the state (Baker, 1906). Records from Kentucky are scarce (type locality and Green River, according to Call, 1885). In the Cumberland it is rare in the main river, but common in the tributaries (Wilson & Clark, 1914). In the Tennessee-drainage it seems to be abundant, from Tennessee and Alabama up to the affluents in Virginia, being found in this region chiefly in the smaller streams. In this region it has also been reported (by Call, 1885) from the French Broad River in North Carolina, and I found it in the Pigeon River in North Carolina.

South of the Tennessee and West of the Mississippi it is absent.

In addition it has crossed over into the lake-drainage in Indiana, St. Joseph River, Michigan basin, and Maumee River (Call, 1896*a*) and Ohio (Sterki, 1907*a*), and is found in the latter state and in southeastern Michigan in the drainage of Lake Erie (Walker, 1898).[201] It is not known to go up in the Allegheny-drainage into New York state, but Marshall (1895) gives it from Medina, Orleans Co., and the Genesee River, Monroe County, in the Lake Ontario-drainage, and from Butternut Creek in Otsego County (tributary to the Susquehanna). These localities should be confirmed, and Simpson treats them as doubtful.

Baker (1898*a*) says that, like *Eurynia iris*, this species is found in lakes and rivers on a sandy or muddy bottom. This is not at all confirmed by my observations in Pennsylvania. In the upper Tennessee-drainage, where the species is abundant, it prefers rather rough parts of the streams, and ascends (in French Broad and Pigeon Rivers) into the high Appalachians in North Carolina.

Lampsilis cariosa (Say) (1817).[202]

Lampsilis cariosa (Say) Simpson), 1914, p. 43.[203]

Plate XX, figs. 3, 4, 5.

Records from Pennsylvania:

Say, 1817 (Delaware and Schuylkill Rivers, Philadelphia).
Haldeman, 1844 (Lancaster Co.).

[201] Maumee River (Dall & Simpson, 1895) and Cuyahoga River (Dean, 1890) in Ohio, and Huron and Detroit Rivers, in Michigan (Walker, 1892, see also material in Carnegie Museum); also reported from Lake Erie proper by Walker, 1913, but never found on the Pennsylvanian shores.

[202] Not 1816.

[203] The figures of Conrad (Mon. 4, 1836, Pl. 19) are fine representations of this species, and the same is true of his figures of *U. ochraceus* (Pl. 17, fig. 2). If subsequent authors had paid due attention to these figures, the prevailing confusion of these two species (and of the related western forms) would have been impossible. DeKay s figures (1843, Pl. 21, figs. 243, 244) surely do not represent *cariosus*, but are *L. ovata ventricosa*. Simpson (1895) on pp. 121 and 122 also figures *cariosus* and *ochraceus*, and

Gabb, 1861 (Delaware River, Tacony, Philadelphia Co., and Bristol, Bucks Co.)
Bruckhart, 1869 (Lancaster Co.)
Hartman & Michener, 1874 (Schuylkill, Delaware, and Susquehanna Rivers).
Pilsbry, 1894 (York Furnace, York Co.)
Schick, 1895 (Delaware River, Philadelphia).
Ortmann, 1909*b*, p. 204.
Caffrey, 1911, reports *U. ochraceus* from the Delaware in Northampton County, but there is no question that under this name he designates *U. cariosus*.

Characters of the shell: Of medium size, rather thin when young, but becoming thicker when old. Outline ovate or subelliptical, rather short and high, but old males are often somewhat elongated, and may be slightly over one-and-a-half times as long as high; but generally the length is less than this. Anterior margin rounded. Lower margin more or less curved. Upper margin short, straight or a little convex, passing into a blunt angle or gradually into the obliquely descending posterior margin. Posterior end a rounded, blunt angle. Beaks moderately swollen, not much elevated, anterior to the middle of the shell. Beak-sculpture (Marshall, 1890, fig. 8) consisting of about five not very distinct bars, the first subconcentric, the following ones slightly double-looped, with a light sinus in the middle, obsolete in the last bars. Upon the posterior slope, the bars are effaced. Valves regularly convex, somewhat flattened upon the sides. Posterior ridge very indistinct, practically absent. Posterior slope gently convex, or almost flat.

Epidermis yellow, very smooth and shining. The yellow is wax- or straw-yellow, with hardly a trace of green in it, but sometimes inclining to brown or reddish brown. Rays either entirely absent, or present upon the posterior slope and a little in front of it. They are variable in width, but are generally fine, straight, and sharply defined, dark green or blackish in color, contrasting strongly with the light epidermis. Concentric bands of light or dark color absent or indistinct. In old specimens the color of the epidermis is less bright, and becomes dirty grayish or brownish yellow.

Hinge well-developed. Pseudocardinals generally two in each valve, quite variable in shape. In young specimens they are rather compressed, in older ones more stumpy and ragged. Interdentum practically absent. Laterals lamellar, generally somewhat elevated and truncate at their posterior ends. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Anterior adductor-scars distinct and impressed, posterior ones less distinct. Nacre silvery white, often suffused with cream- or salmon-color, but not reddish.

later (1900, p. 529, footnote 1, and p. 530, footnote 2) says, that the two figures had been accidentally transposed. But these figures are copies from Hartman & Michener (1874, figs. 183, 184) where the same mistake is made. I think, both of these figures represent *cariosus*, and the one named *ochraceus* is certainly the female of *cariosus*.

Sexual differences of shell strongly marked. In the male, the lower margin is more regularly convex, joining the posterior margin in a blunt posterior point, and the outline of the shell is more regularly elliptical. In the female, the lower margin is considerably expanded in the posterior region, sloping up very strongly to the blunt posterior end, so that the posterior part of the shell is higher and more broadly rounded.

		L.	H.	D.
Size:	(Males) 1. Selinsgrove, Cat. No. 61.4894	122 mm.	80 mm.	51 mm.
	2. Duncannon, Cat. No. 61.3416	113 "	74 "	41 "
	3. Yardley, Cat. No. 61.3417	80 "	50 "	32 "
	(Females) 4. York Haven, Cat. No. 61.4893	96 "	71 "	44 "
	5. South Waverly, Cat. No. 61.4003 (gravid)	91 "	67 "	46 "
	6. Yardley, Cat. No. 61.3417 (gravid)	70 "	52 "	36 "

Soft parts (See Ortmann, 1912, p. 352). *Glochidia, ibid.* (the latter not fully known, only immature individuals having been observed).

Breeding season: Gravid females were observed on the following dates: Aug. 13, 1908; Aug. 14, 1908; Aug. 14, 1910; Aug. 20, 1909; Aug. 22, 1909; Aug. 24, 1908. Only on the last date were glochidia (immature) found; all other specimens had only eggs. But just these meagre facts establish the beginning of the breeding season in August, and very probably this species agrees with the allied forms, and is *bradytictic,* discharging the glochidia in the subsequent spring or early summer.

Remarks: An exceedingly well defined species, easily recognized. Nevertheless great confusion prevails with regard to it. This confusion is principally due to the fact that De Kay (1843) misunderstood this and some allied species, and that the two sexes of *cariosus* were regarded as different species by other authors (Gould-Binney, and Hartman & Michener). Simpson (1895) tried to straighten out the confusion, but unfortunately copied two old erroneous figures, and committed an additional error, and thus it has happened that even some recent authors (Conner, 1909, and Caffrey, 1911) confused this species with *L. ochracea.*

L. cariosa is allied to the western *L. ovata ventricosa,* but is smaller than the latter, in the male sex is more regularly elliptical, has hardly a trace of a posterior ridge, and is entirely and characteristically different in color and color-markings. The bright and light yellow of the epidermis and its high gloss are entirely different from the greenish-olive tints of *L. ovata ventricosa,* and the restriction of the rays (if such are present) to the posterior section of the shell is also characteristic. Of course, these characters are best seen in young or medium-sized individuals, while in older specimens the smoothness disappears, and the color becomes more dirty: nevertheless even in very old shells the light yellow is generally present at least on

certain parts of the shell. This color is so eminently characteristic, that even laymen have noticed it, and people living on the banks of the Susquehanna and Delaware properly distinguish this species as the "yellow clam."

The variation of this species occurs chiefly in the external shape (more or less elongate) and the development of the rays. Moreover the yellow of the ground-color varies slightly, being lighter or more intense, often inclining toward reddish brown in parts of the shell.

Localities in Pennsylvania represented in the Carnegie Museum:

Delaware River, Taylorsville (C. H. Conner) and Yardley, Bucks Co.; Shawnee, Monroe Co.[204]
Susquehanna River, York Furnace and York Haven, York Co.; Duncannon, Perry Co.; Selinsgrove, Snyder Co.
Conewago Creek, York Haven, York Co. [205]
Juniata River, Juniata Bridge, Perry Co.; Lewistown, Mifflin Co.
Frankstown Branch, Juniata River, Huntingdon, Huntingdon Co. (D. A. Atkinson).
Raystown Branch, Juniata River, Ardenheim, Huntingdon Co.
West Branch Susquehanna River, Williamsport, Lycoming Co. (D. A. Atkinson).
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.

Other localities represented in the Carnegie Museum:

Connecticut River (Hartman collection).
Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner).
Potomac River, Cabin John, Montgomery Co., Maryland (J. D. Haseman); Mount Vernon, Fairfax Co., Virginia (Juny collection).
Savannah River (Hartman collection).[206]

Distribution and Ecology in Pennsylvania (See fig. 31): This species belongs to the Delaware and Susquehanna drainages in Pennsylvania, but has not been found in the small tributaries of the Potomac in our state. In the Delaware River it goes up to above the Delaware Water Gap, but its scarcity just above the gap indicates, that at this point it approaches the upper limit of its range. In the Susquehanna it is practically everywhere, ascending at least to Williamsport, Lycoming Co., in the West branch, and to the New York state line in the North

[204] Shawnee is immediately above the Delaware Water Gap: only one specimen was found here and no dead shells were lying around.

[205] In the lowermost part only of this creek, where there is at times water from the Susquehanna.

[206] A large, thick-shelled specimen, labeled *rosaceus* Conrad, agrees well with Conrad's description, but is larger, and has only a faint blush of pink on the nacre. In other respects it agrees likewise with *cariosus*, and, although discolored, the epidermis shows remnants of the gloss. If locality and identification are correct, *rosaceus* is a form of *cariosus*, not of *ochraceus* (of which Simpson makes it a synonym). Whether this form is different from *cariosus* (as variety or species) cannot be decided from a single individual.

branch. It is generally restricted to the main river, and only enters some of the larger tributaries, for instance the Schuylkill, Juniata, and Chemung Rivers. In the smaller tributaries it is absent, and the only specimen found by myself in Conewago Creek, was in its lowermost part, which, during high water forms a branch of the Susquehanna.

Where found this species is generally abundant, even in smaller streams like the Juniata in Huntingdon County, where it reaches its farthest advance in the mountains. It is always found in lively currents, on shoals and riffles, in finer or coarser gravel, and very often in bars of pure sand. Although it has been reported from the tidewater region of the lower Delaware, it does not seem to be abundant there (I did not find it near Fish House, Camden Co., New Jersey).

In Pennsylvania its metropolis is apparently the Delaware from Trenton upward, and the Susquehanna from the region of York Haven to the point where the West and North branches unite.

General distribution: Type locality, Delaware River, Philadelphia (Say).

According to Simpson (1900) this species is found in the "Atlantic-drainage from Georgia to the lower St. Lawrence," but this possibly requires some restriction. Its occurrence in the lower St. Lawrence is extremely questionable, and rests chiefly upon the statement of Marshall (1895), who also gives it from Maine (confirmed by Lermond, 1909, and Johnson, 1915). It is undoubtedly found in Massachusetts and Connecticut (Gould-Binney, 1870, Marshall, 1895, Linsley, 1848, Johnson, 1915). From New York it has been reported (Marshall, 1895) from the Hudson-drainage up to, and even above, Albany, and there seems to be even a western extension of the range through the Erie canal to Onondago and Ontario Counties, but this should be investigated again, since it is not quite sure that Marshall understood this species correctly. De Kay (1843) reports it from the Passaic River, Belleville, Essex Co., New Jersey, and the species should exist there: however, De Kay's figures represent, as has been said, *L. ovata ventricosa*. Marshall (1895) gives it from the Raritan River, Somerville, Somerset Co., New Jersey. Its distribution in Pennsylvania has been discussed above. From Delaware it is known from Seaford, Sussex Co. (Rhoads, 1904). From the Potomac River it has been reported from the District of Columbia and from the canal at Alexandria, Fairfax Co., Virginia (Marshall, 1895), and it is found in Maryland above Washington. However, it does not ascend far up in this river, and is surely absent in the whole Potomac-drainage West of the Blue Ridge.

To the South of the Potomac, records become very scarce. Conrad (1836) says that it is rare in the Potomac as well as in the James River, and since Conrad

correctly understood the species, we must accept this latter locality. "Georgia," given by Simpson, probably rests upon Conrad's record of *U. oratus* from Flint River, and if *U. rosaceus* Conrad should actually belong here, we would also have to include the Savannah River. However these southern localities emphatically need confirmation in view of the fact that from the James River southward, in Virginia and the Carolinas, not a single reliable record is at hand.

As to the standing of this species in the Atlantic fauna, see Ortmann, 1913*a*, pp. 325 & 363.

LAMPSILIS OCHRACEA (Say) (1817).[207]

L. ochracea SIMPSON, 1914, p. 49.[208]

Plate XX, figs. 6, 7.

Records from Pennsylvania:

Say, 1817 (Delaware and Schuylkill Rivers, " with the preceding," namely *U. cariosus*).
Conrad, 1836 (Delaware and Schuylkill Rivers).
Gabb, 1861 (Schuylkill and Wissahickon, Philadelphia; League Island, Philadelphia).
Schick, 1895 (Delaware River, Philadelphia).
Marshall, 1895 (Philadelphia).

Hartman & Michener have confounded this species with *L. cariosa*, and their records: Schuylkill, Delaware, and Susquehanna are unreliable. This species has never been found in the Susquehanna in Pennsylvania. Caffrey (1911) records it from the Delaware, Northampton Co., but he certainly refers to *L. cariosa*. See also Ortmann (1909*b*, pp. 204 & 209).

Characters of the shell: Having only scanty material at hand, I confine myself to giving only the characters of this species differentiating it from its allies, chiefly *L. cariosa*.

L. ochracea is a rather small, thin shell, much thinner than *L. cariosa*, and much thinner and smaller than any of its western relations (*ventricosa, fasciola*). It resembles these in outline, but is mostly somewhat shorter than *L. cariosa*, and has a slightly more distinct posterior ridge. The chief difference is in the epidermis, which does not have the gloss of *L. cariosa*, and becomes quite rough toward and on the posterior slope. The color is dull, not bright yellow, but grayish, greenish, yellowish, or brownish olive, a grayish green being the prevailing hue; and the rays have a different character. Sometimes the latter are entirely absent, but (when present) they are not sharp and blackish, but indistinct, and grayish or grayish green, rather fine, and cover all or a large portion of the surface. Upon the posterior slope, the rays are obscure, and sometimes somewhat wider.

[207] Not 1816.

[208] The figures of DeKay (1843, Pl. 19) do not represent this species, but *L. radiata* (See above, p. 292, footnote 191). Very probably the figure of Gould-Binney (1870, p. 174, fig. 476), and certainly that of Hartman & Michener (1874, p. 89, fig. 184) represent females of *L. cariosa*. There is only one good figure of this species, that of Conrad (Mon. 4, 1836, Pl. 17, fig. 2) which represents the male.

The nacre in all my specimens is silvery white, but is said to be sometimes more or less reddish. Corresponding to the thinness of the shell, the hinge-teeth are delicate, thin, and compressed. The sexual differences of the shell are similar to those of *L. cariosa*. Beak-sculpture as described by Marshall (1890, fig. 7), and resembling that of *L. cariosa*, but the median sinus of the bars is very indistinct or even missing. I have only a single individual which shows the beak-sculpture.

	L.	H.	D.
Size: 1. Newbold, Cat. No. 61.4012 (♂)	62 mm.	42 mm.	26 mm.
2. do. " " do. (♀)	46 "	30 "	20 "
3. Plymouth, Cat. No. 61.667 (♀)	38 "	29 "	18 "
4. Princeton, Cat. No. 61.1571 (sex ?)	32 "	22 "	13 "

This species grows somewhat larger, but the largest male given above is about the average size.

Soft parts and *glochidia* practically unknown. Lea (Obs. II, 1838, Pl. 15, fig. 44) has given a poor figure of the soft parts of a gravid female, and an incomplete description (Obs. X, 1863, p. 455).

Breeding season: Through Lea (Obs. II, 1838, p. 54) we know that this species is gravid in autumn (October, November). Lea also reports (*l. c.*, p. 57) a female charged with eggs for June 5. Conner (1909) has confounded this species with *L. cariosa*, and thus we cannot depend on his dates.

Remarks: This species has been often misunderstood and confounded with *L. cariosa*. In general terms it may be defined as a rather small and thin shell, with dull-colored epidermis, and fine, indistinct, or missing rays, which, when present, cover a larger part of the shell than is the case in *L. cariosa*.

Localities represented in the Carnegie Museum:

Plymouth, Plymouth Co., Massachusetts (Hartman collection).
Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner) (received as *L. cariosa*).
Lake Wacamaw, Columbus Co., North Carolina (G. H. Clapp, donor).

Localities represented in the Philadelphia Academy.

Ditches of Delaware Meadows, League Island, Philadelphia, Pa.
Delaware River, Westville, Gloucester Co., New Jersey (Morris Schick).
Delaware River, Kaighns Point, Camden, Camden Co., New Jersey (John Ford).

Distribution and Ecology (See fig. 31): *Type locality*, Delaware River, Philadelphia (Say).

According to Simpson (1900) this species is in the "Atlantic-drainage, from New England to the Ogeechee River, Georgia," that is to say, it occupies about

the same range, as that given by him for *L. cariosa*. But, as we have seen, in the south *L. cariosa* is doubtful.

The species has been reported from Maine (Marshall, 1895; Lermond, 1909), from Massachusetts (Earle, 1835; Gould-Binney, 1870; Marshall, 1895), from Connecticut (Linsley, 1845) (See also New England localities given by Johnson, 1915). It is known from the Hudson in New York, and is said to go up here to Albany and the Mohawk River, Herkimer Co. (Marshall). In Pennsylvania, it is restricted to the lower Delaware, and the lowlands near to it. It has been found in the lower Schuylkill and also Wissahickon Creek. According to specimens I have seen in the Philadelphia Academy, it is abundant in the ditches of the meadows near League Island. It is unknown from the Susquehanna and Potomac drainages in Pennsylvania, although known from the lower Potomac in the District of Columbia (Marshall), Prince George Co., Maryland (Lea, Obs. X, 1863, p. 456), and Fairfax Co., Virginia (Marshall). Rhoads (1904) reports it from Seaford, Sussex Co., Delaware, and farther south it is abundant in the lower James River, Virginia (Conrad, 1836) and according to the same author in "most tide-waters north of the Savannah River." The most southern record is that of Simpson from the Ogeechee River in Georgia.

In Pennsylvania, *L. ochracea* is decidedly rare, and restricted to the tide-waters of the Delaware. It is not at all coëxtensive with *L. cariosa*, since the latter ascends the rivers for a considerable distance. The same seems to be true in other parts. Most of the exact localities known are in the tidewater-regions of the Atlantic streams, and Conrad calls especial attention to this. Thus the ecological preferences of this species seem to be for the estuaries of our large rivers. In the Hudson it goes up quite far, but in the vicinity of Albany it has been reported chiefly from canals, and it seems that it also frequently inhabits canals and ponds. I found it myself in the Delaware-Raritan Canal in New Jersey. Thus the species differs ecologically from *L. cariosa*. It is a form of estuaries, ponds, canals, and ditches, probably with more or less muddy bottoms, while *L. cariosa* favors large rivers, with sandy and gravelly bottoms and strong currents. A closer study of these conditions is very desirable (See Ortmann, 1913*a*, pp. 325, 368).

Lampsilis orbiculata (Hildreth) (1828).

Lampsilis orbiculata (Hildreth) Simpson, 1914, p. 76.

Plate XX, fig. 8; Plate XXI, figs. 1, 2.

Records from Pennsylvania:

Clapp, 1895 (Allegheny Co.)
Ortmann, 1909*b*, p. 190.

Characters of the shell: Of medium size to rather large (but not as large as *L. ovata*), extremely thick and heavy (one of the heaviest shells for its size). Outline subelliptical or subovate, very variable and often irregular, chiefly so in the female, always less than one-and-a-half times as long as high. Anterior margin rounded. Lower margin convex, sometimes rather uniformly so, but in other cases the middle part of the lower margin is less convex, and the posterior part slopes up rather steeply. Upper margin short, gently convex, passing gradually into the obliquely descending posterior margin, without forming a distinct angle. Posterior and lower margins uniting posteriorly in a blunt angle, which may be obliterated. Beaks moderately swollen, and little projecting above the hinge-line, more or less inclined forwards, and located in front of the middle of the shell. Beak-sculpture obsolete. Although I possess specimens with fairly well preserved beaks, I cannot see any distinct beak-sculpture. Valves more or less convex, generally moderately so, but old specimens, chiefly females, are much more convex (almost globular). The convexity is least upon the sides, greatest in the region of the posterior ridge. The latter, however, is quite indistinct. Posterior slope slightly convex or flattened, narrow.

Epidermis brown, light or dark yellowish brown or reddish brown, generally without any trace of green shades. This color is rather uniform, and no concentric bands of light and dark are present. Rays either absent (chiefly in older shells), or, when present, faint and indistinct. In young, well-preserved specimens, the rays are fine or moderately wide, but not dark (black or dark green), but gray or grayish green, or brownish. They are not sharply contrasted with the ground-color, and disappear toward the lower margin, so that older shells have rays only near the beaks. In very old specimens the general color becomes uniformly dirty brown, but not very dark brown.

Hinge well developed. Pseudocardinals two in left, one or two in right valve (the anterior one smaller), variable in shape, strong, stumpy and ragged. Interdentum narrow. Laterals moderately long, slightly curved, thick and heavy. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct, all deeply impressed, the posterior scars less so. Nacre silvery white, very often with more or less pink, chiefly in the beak-cavity and near the hinge, and sometimes the whole interior of the shell is suffused with beautiful salmon or pink. But in other cases the pink shades may be entirely absent.

Sexual differences of the shell very strongly marked. In the male the outline is rather regularly subovate or subelliptical, with the lower margin rather regularly curved, meeting the posterior margin in a blunt point. In older males

the lower margin may be almost straight in the middle, and the posterior end may be rounded off. In the female the lower margin projects in the postbasal region, so that the anterior and middle part is almost straight, and the posterior part ascends very suddenly, forming with the part in front a more or less distinct rounded angle, and joining the posterior margin in a very blunt angle. Thus the posterior part of the female shell becomes very high, and in old females this may go to such an extreme that the height of the shell nearly equals the length, thus rendering the outline almost orbicular. In some cases such old females are also much more convex, so that the whole shell approaches the globular shape.

		L.	H.	D.
Size:	(Males) 1. Portsmouth, Cat. No. 61.4898	103 mm.	75 mm.	61 mm.
	2. Neville Island, Cat. No. 61.2046	100 "	76 "	57 "
	3. Kelly, Cat. No. 61.3017	80 "	59 "	36 "
	(Females) 4. Industry, Cat. No. 61.3500 (gravid)	92 "	83 "	57 "
	5. do. " " do.	89 "	70 "	49 "
	6. Godfrey, Cat. No. 61.3504	74 "	57 "	34 "

The largest specimen I have seen is from the Clinch River, at Offut, Anderson Co., Tennessee, and measures: L. 104, H. 82, D. 53 mm. It has the shape of the female.

Soft parts (See Ortmann, 1912, p. 353). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 22).

Breeding season: The following records for gravid females are at hand. Aug. 10, 1909; Aug. 24, 1910; Aug. 29, 1908; Sept. 8, 1908; Sept. 10, 1908; Sept. 12, 1914; Sept. 17, 1908; Sept. 23, 1908. Sept. 8 is the earliest date for glochidia. A female just discharged was collected in Ouachita River by Mr. Wheeler on June 26, 1911.

This is apparently a *bradytictic* form, beginning to breed in August, having glochidia in September, which are discharged the next spring (June).

Remarks: This species, when well-developed, is easily recognized by the extremely heavy shell, by the brown color with indistinct rays, and the general presence of a delicate pink color in the nacre. However, it is very variable with regard to shape. The males, and chiefly the young males, very much resemble *Actinonaias ligamentina*, so much so in fact, that this species has been placed by the side of *L. ligamentina* in Simpson's system. Yet there is no close relationship between the two species. Young males of *L. orbiculata* differ from *A. ligamentina* by the brown color of the epidermis, and the indistinct and finer rays: however, sometimes the latter species also has a brownish epidermis, and in such cases it is hard to separate them.

The female of *L. orbiculata* is entirely different from that of *A. ligamentina* in shape. The posterior dilatation is not found in *A. ligamentina*, and the latter never approaches the globular shape.

Both male and female of *L. orbiculata* often present freakish shapes, and the proportion of length and height, convexity of the valves, and curvature of the lower margin is hardly alike in any two specimens.

A very good character, excepting in the case of very young shells, is always the thickness of the shell. In fact for its size this species is possibly the heaviest shell of the Ohio-drainage.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Neville Island, Allegheny Co.
Allegheny River, Godfrey and Kelly, Armstrong Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Other localities represented in the Carnegie Museum:

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Clinch River, Solway, Knox Co., and Offutt, Anderson Co., Tennessee.
Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Andalusia, Rock Island Co., Illinois (A. D. Howard).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler); Pocahontas, Randolph Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).[208a]

Distribution and Ecology in Pennsylvania (See fig. 33): This is a rare shell in Pennsylvania, and is only found in the larger rivers. The largest number of specimens has been secured in the Ohio in Beaver County, but here also it is by no means abundant. It used to be in the Ohio in Allegheny County, and in the Monongahela as far up as Charleroi, Washington Co. (only one individual is at hand from this locality). It also ascends the Allegheny to Armstrong County, but here it is extremely rare, and only a few specimens were taken.

So far as I am able to judge, it is a shell of strong currents in large rivers. I found all my specimens on riffles; but farther down in the Ohio it is present upon

[208a] See Wheeler (1918, p. 117). Specimens from the Ouachita River agree very well in shape with specimens from the Ohio River and the color of the epidermis is of the same brown hue in some of them, but in others it is more brownish-olive (with a suggestion of green). They are surely not *L. higginsi*, because the beaks are not at all inflated. The form from Black River is remarkable on account of its rays, which are broad and distinct; and also by the brownish-olive epidermis. It belongs to the forms intergrading with *L. higginsi* (Lea).

the shell-banks, among other bed-forming species. But here also it is not very frequent, and the shell-heaps of the clam-diggers contain only small numbers. These conditions remain the same all the way down to Portsmouth. Every specimen found by myself has been taken, but the total sum collected from the Ohio below Pennsylvania hardly amounts to two dozen.

General distribution: Type locality, Muskingum River, Marietta, Washington Co., Ohio (Hildreth).

This species is found extending from western Pennsylvania down the Ohio in the states of West Virginia, Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a*), and probably also Illinois and Kentucky. In the upper parts of the Ohio-drainage it hardly goes into the tributaries. The type locality, Muskingum River, has remained so far the only tributary, which contains it in Ohio. In Indiana it is also found in the Wabash and White Rivers (Say, 1817, Call, 1896*a* and 1900), and in Illinois (Baker, 1906) it is in the Wabash and in the Illinois River (as far up as La Salle Co.). It is in the Mississippi River in Illinois as well as in Iowa (Davenport, Scott Co.) according to Pratt (1876). Simpson (1900) says that it ascends the Mississippi to Minnesota, but it has not been reported by Grant (1886) and Holzinger (1888), and is not reported from Wisconsin by Lapham (1860).

From the southern tributaries of the Ohio it is known from the Cumberland River (Call, 1885; Simpson, 1900; Wilson & Clark, 1914) and in the Tennessee, it goes up to the Clinch River in Anderson Co., Tennessee.

West of the Mississippi previous records are scarce or doubtful. While Call (1885) gives this species from Blue River in Kansas, Scammon (1906) records *L. higginsi* for this river. The latter species, according to Simpson, is found from the (probably lower) Ohio west to Iowa and southwest to Kansas.[209] However, specimens sent to me by H. E. Wheeler from Ouachita River in Arkansas are undoubtedly *L. orbiculata,* and thus the latter certainly goes southward to the Ouachita River. Specimens from Black River, however, distinctly incline toward *higginsi.* Utterback (1916) has only *higginsi* from Missouri, but not *orbiculata.*

It is quite possible that *L. higginsi* is merely a local form of *L. orbiculata,* the form of very large rivers with muddy bottoms. We have repeatedly seen in other species that inflation of the beaks is a character of big-river-forms. If this is another case of this kind, the relation of the Ouachita and Black River *orbiculata* to that of the Ohio could be explained as that of an ecological race. Of course, additional material should be studied. That there might be intergrades is indicated by our specimens from Muscatine, which incline somewhat toward *higginsi*

[209] As far as I can see *L. higginsi* (Lea) differs from *L. orbiculata* chiefly in the more inflated and more elevated beaks, and in the color of the epidermis, which has more green in it.

by their slightly more elevated beaks and their more brownish-olive epidermis, and by specimens of the same character from Black River, as well as by a specimen from the Mississippi at Andulusia, received together with typical *orbiculata*.

Genus Truncilla Rafinesque (1820).

Ortmann, 1912, p. 354; Simpson, 1914, p. 2.

Type *Truncilla triquetra* Rafinesque.

Simpson (1900) has divided the genus into four subgenera (*Truncilla, Scalenaria, Dysnomia, Pilea*) while Walker (1910) in a recent revision of the genus, admits three main groups, which properly might be regarded as subgenera. Investigations of the soft parts, however, probably will require some alterations of this arrangement. I prefer to ignore the subgenera for the present, since there are only two species in Pennsylvania, the first one (*triquetra*) being a true *Truncilla*, while the second (*rangiana*) would fall under Simpson's *Pilea*. The rest of the species are chiefly found in the Tennessee-Cumberland region.

Key to the Pennsylvanian Species of Truncilla.

a_1. Shell with a very distinct posterior ridge, and distinctly truncate posterior slope. Inflation of female shell narrow, very convex, restricted to the posterior ridge, not differing from the rest of the shell in texture, and denticulated on the margin. Rays strongly spotted..... *T. triquetra.*

a_2. Shell with a very indistinct posterior ridge, and the posterior slope not truncate. Inflation of the female shell very broad and flat, occupying the whole postbasal area, with the nacreous layer poorly developed, not denticulated on the margin. Rays simple, not spotted..... *T. rangiana.*

Truncilla triquetra Rafinesque (1820).

Truncilla triquetra Rafinesque, Simpson, 1914, p. 5.

Plate XXI, figs. 3, 4.

Records from Pennsylvania:

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.)

Ortmann, 1909*b*, p. 188.

Characters of the shell: Small, moderately thick. Outline subovate to subtrapezoidal and subtriangular. Anterior margin rounded. Lower margin gently curved, but sometimes (chiefly in the female) straight or even slightly emarginate posteriorly. Upper margin very short, passing in old specimens into the obliquely descending posterior margin without forming an angle (shape triangular), but in young specimens there is generally an angle (shape trapezoidal). Posterior margin forming a rather distinct, but more or less rounded, angle with the lower margin. This angle is situated very low, only a little elevated above the base-line. Beaks

moderately swollen, and moderately elevated above the hinge-line, located in front of the middle of the shell, but not very near the anterior end. Beak-sculpture rudimentary, consisting of about three faint, indistinct bars, which have a tendency to fall into two loops. Valves greatly swollen, but rather flat upon the sides, convex anteriorly, and with a very distinct and strong, but blunt, posterior ridge; no furrow or depression in front of the latter. Behind the posterior ridge the posterior slope is sharply truncate and flat, being very little elevated in the middle.

Epidermis yellowish, yellowish green, or light green, always with well developed dark green to blackish rays, which are distinct, broad and bold, and generally have the tendency to become dissolved into squarish, triangular, or sagittate spots. In most cases the rays cover all of the lateral faces of the shell, but they are indistinct or entirely absent on the posterior slope. In old specimens the rays disappear toward the lower margin. Concentric bands of color are indicated chiefly by a tendency to have the spots of the rays arranged in concentric lines.

Hinge well-developed. Pseudocardinals generally two in each valve, but the anterior tooth in the right valve is small. The teeth are strong, stumpy, ragged. Interdentum absent. Laterals of medium length, strong. Beak-cavity moderate. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct, and anteriorly strongly impressed, less so posteriorly. Nacre always silvery white.

Sexual differences of the shell very strongly marked. The male has a rather regular, subtriangular outline, with the posterior ridge moderately elevated, the greatest diameter of the shell situated slightly in front of the ridge, and with a moderately broad posterior slope, without sculpture, and with the edge of the shell entire. In the female the marsupial expansion is located on and restricted to the posterior ridge. In consequence of this the posterior ridge is greatly elevated, and the greatest diameter of the shell is located upon the posterior ridge, and in old females the diameter of the shell often exceeds the height of the shell (a proportion quite unique among Naiades). The posterior slope in the female is greatly enlarged, and in addition there is a sculpture of radial ribs upon the posterior ridge and posterior slope, which produces a denticulation on the margin of the shell in this region. This sculpture may be present, in a rudimentary condition, in old males. The general outline of the female shell is a little different, the posterior end projecting slightly beyond the line of the lower margin, so that there is a slight concavity of the lower margin in front of the posterior end. The female shell does not nearly attain the size of the male shell.

		L.	H.	D.
Size:	(Males) 1. Kelly, Cat. No. 61.2983	68 mm.	44 mm.	36 mm.
	2. Shenango, Cat. No. 61.4097	60 "	41 "	31 "
	3. Aladdin, Cat. No. 61.3358	52 "	34 "	25 "
	4. do. " " do.	40 "	27 "	20 "
	(Females) 5. Kelly, Cat. No. 61.2985 (gravid)	45 "	25 "	28 "
	6. Aladdin, Cat. No. 61.3358 (gravid)	42 "	26 "	31 "
	7. Aladdin, Cat. No. 61.3358 (gravid)	38 "	22 "	19 "
	8. Godfrey, Cat. No. 61.3360 (gravid)	37 "	22 "	18 "

The largest individuals recorded here are not surpassed by any specimens from outside of Pennsylvania.

Soft parts (See Ortmann, 1912, p. 355, fig. 27). *Glochidia* (See Ortmann, 1911, Pl. 89, fig. 24).

Breeding season: Gravid females were found on Sept. 5, 1913; Sept. 8, 1914; Sept. 15, 1913; Sept. 16, 1913; Sept. 17, 1913; Sept. 18, 1908; Sept. 27, 1907; Sept. 27, 1909; Oct. 5, 1908; Then again on May 20, 1914; May 23, 1911; May 24, 1911.

Glochidia have been observed as early as Sept. 17. On May 20 and 23, discharging females have been found. Thus this species is clearly *bradytictic.*

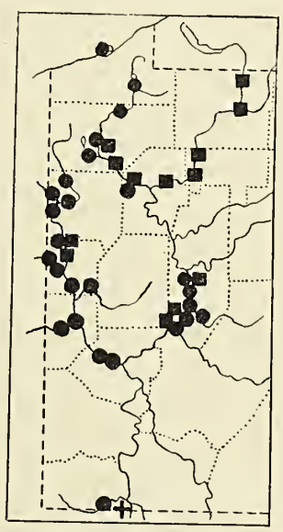


FIG. 34.

● *Truncilla triquetra.*
■ *Truncilla rangiana.*
\+ Do. (Indian garbage heap).

Remarks: The female of this species is so peculiar in shape and color, and in possessing the remarkable character of denticulations on the margin of the shell,

that it cannot be confounded with any other species. The male also is quite well-defined by its subtriangular shape, strong posterior ridge, and truncate posterior slope, and also its color-pattern. However, to a certain degree the male resembles *Amygdalonaias truncata* (Rafinesque) but the latter is a higher and more compressed shell, with the posterior ridge sharper, chiefly in the region of the beaks, and with the posterior slope narrower and less distinctly truncate.

There is a good deal of variation in the shell of *Truncilla triquetra*. Aside from the general outline, which is more subtrapezoidal in young shells, and more subtriangular in old ones, there is variation in the elongation of the shell. In old males the posterior end is often considerably drawn out. Both males and females vary greatly in diameter and in the width of the posterior slope, which in some old females becomes really freakish. There is also great variation in the color-pattern, and the rays and the spots are hardly ever alike in any two specimens.

The Lake Erie form of this species does not seem to differ from the normal type. I have only few specimens from the lake, which compared with specimens from the Ohio are of about medium size, and seem to be slightly lighter in color.

Localities in Pennsylvania represented in the Carnegie Museum:

Ohio River, Neville Island, Allegheny Co.[210]
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).[211]
Mahoning River, Mahoningtown and Edinburg, Lawrence Co.
Shenango River, Pulaski, Lawrence Co.; Sharpsville, Clarksville, and Shenango, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, Mosgrove, and Templeton, Armstrong Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Meadville and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Dunkard Creek, Mount Morris, Greene Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

Other localities represented in the Carnegie Museum:

Lake-drainage:

Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

Ohio-drainage:

Ohio River, Portland, Meigs Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Miami River, Ohio (Juny collection).

[210] A dead shell has been seen at Industry, Beaver Co.

[211] A dead shell has been seen in Slipperyrock Creek, at Wurtemberg, Lawrence Co.

Big Beaver Creek, Mercer Co., Ohio (C. Goodrich) (Wabash-drainage).
West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.

Tennessee-drainage:

Duck River, Columbia, Maury Co., Tennessee (G. H. Clapp, donor).
Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Flint River, Maysville, Madison Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).
Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.
Holston River, McMillan and Mascot, Knox Co.; Turley Mill and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia.
Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia.
Powell River, Combs, Claiborne Co., Tennessee.

Distribution and Ecology in Pennsylvania (See fig. 34): This is a widely distributed species in the Ohio-drainage in western Pennsylvania, but is not found anywhere in great numbers. In the Ohio proper below Pittsburgh I found only a few dead shells. It is present in the Beaver-drainage, but is not very abundant. In the Allegheny in Armstrong Co. it is not rare, and in this region enters some of the tributaries, as Crooked Creek, and farther up, French Creek, penetrating well into the headwaters. It has not been found in the Allegheny above Oil City.

In the Monongahela-drainage, this species is extremely rare, and I found it only in Dunkard Creek. However, farther up in the headwaters in West Virginia it is rather abundant, as in West Fork River, where at Lynch Mines I secured the largest number of specimens in all my collecting.

In addition this species is present in Lake Erie, but here it is extremely rare. I found only a single dead shell in Presque Isle Bay.

Truncilla triquetra distinctly belongs to those species, which inhabit riffles. Wherever I found it, it was on riffles, and (at low stage) in quite shallow water, in strong currents. Here it is deeply buried, and only the truncated posterior slope is exposed, so that in the natural position the shell offers a very peculiar aspect; only the flat, broadly lanceolate posterior slope is exposed to view, differing entirely from the dark slit generally seen in other Naiades (formed by the

anal and branchial openings). The bottom at these localities generally consists of finer or coarser, closely packed gravel; but I have also found this species in pure sand, when the latter is not kept moving by the current. In Lake Erie, in Presque Isle Bay, of course, this species must live in the fine sand of the bay: but I did not find it alive there.

General distribution: Type locality, Falls of the Ohio (Rafinesque) (at Louisville, Jefferson Co., Kentucky).

Simpson (1900) gives the following range: "Ohio River-drainage; western New York to southern Michigan; Iowa; eastern Nebraska to Indian Territory." In the Ohio-drainage, this species is generally distributed, not only in the Ohio proper, where it seems to be scarce, but also, and chiefly so, in the tributaries. It goes rather far up in the smaller streams. From Pennsylvania it goes through West Virginia and Ohio to Indiana and Illinois. Here it goes up into the Kankakee River and to Will Co. (Baker, 1906), but is not in the "Chicago area."

Records from the southern tributaries of the Ohio in Kentucky are scarce, but it is in the upper Cumberland and its tributaries (Wilson & Clark, 1914), and in the Tennessee to northern Alabama and eastern Tennessee, where it reaches, in the Clinch and North Fork of the Holston River, into the state of Virginia.

Farther to the west, it has been reported from the Mississippi River in Iowa (Pratt, 1876; Witter, 1878; Marshall, 1895), but not farther north. Simpson records it from eastern Nebraska, and it exists in eastern Kansas (Scammon, 1906), and also, according to Simpson, in Oklahoma. However, there are no records from Missouri (see Utterback, 1916) and Arkansas, and southward, and none from the Alabama-drainage.

T. triquetra has, however, crossed over into the lake-drainage, and it is found in this drainage in Ohio (Sterki, 1907*a*), in southern Michigan (Walker, 1898), and in Lake Erie (Walker, 1913). Here it goes eastward to the state of New York, and the locality "New York" (Call, 1885; Simpson, 1900) is supported only by definite records from Buffalo and Niagara River (see Marshall, 1895).[212]

As in Pennsylvania so elsewhere this species seems to prefer riffles, with rough bottoms and strong currents.

[212] It might be in the upper Allegheny in New York, but, as has been said, I never found it in the Allegheny above Oil City.

Truncilla rangiana (Lea) (1838).

Truncilla perplexa rangiana (Lea) Simpson, 1914, p. 25.[213]

Plate XXI, figs. 5, 6, 7.

Records from Pennsylvania:

Marshall, 1895 (as *U. perplexus* Lea from the Allegheny River, Warren Co.; this undoubtedly is *T. rangiana*).

Ortmann, 1909*b*, p. 188.

Characters of the shell: Shell rather small (but larger than that of *T. triquetra*), moderately thick, but extremely thin at the postbasal expansion of the female. Outline irregularly subovate. Anterior margin rounded. Lower margin of the male convex in front, straight or concave, and ascending in the posterior part; this posterior part forms a blunt, more or less distinct angle with the anterior part. In the female the lower margin forms a more or less distinctly double curve, the posterior part more strongly convex, and the two parts are separated by a short concavity or notch. Upper margin moderate, passing in a blunt angle or gradually into the obliquely descending posterior margin. In the male the posterior and lower margins meet in a blunt posterior point, which is situated well above the basal line; in the female the posterior end of the shell is broadly and evenly rounded. Beaks not much swollen, and little elevated above the hinge-line, located in front of the middle of the shell, and only a short distance away from the anterior end. Beak-sculpture rudimentary, consisting of three or four faint bars, which are double-looped. Valves rather compressed, moderately and rather evenly convex in the anterior part of the shell. In the male there is a blunt and indistinct posterior ridge, and in front of this a broad and shallow radial furrow, running from the beak to the posterior part of the lower margin. In front of this furrow the shell is often somewhat elevated, forming a blunt rib running toward the angle in the middle of the lower margin. Posterior slope narrow, gently convex or flattened, not truncate. In the female the region of the furrow and of the posterior ridge is occupied by a broad and somewhat flattened expansion, in front of which there is a more or less distinct, narrow constriction in old specimens. Posterior ridge and posterior slope entirely indistinguishable in the female.

Epidermis yellow or greenish olive, generally with rather distinct, fine, and crowded, straight and uninterrupted, dark green rays. These rays may cover practically the whole surface, but in old specimens they disappear toward the lower margin and upon the posterior expansion, which often is of a lighter color

[213] *U. gubernaculum* Reeve, 1865, Pl. 28, fig. 146, is not this form, as Simpson believes, but a variety of *T. torulosa* (Rafinesque) (= *perplexa* Lea) found in the headwaters of the Tennessee River.

than the rest of the surface. Concentric dark bands, marking growth-rests, are more or less distinct.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, stumpy, ragged. Interdentum absent. Laterals moderately long, moderately strong. Beak-cavity rather shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct and well impressed, chiefly those in front. Nacre always white.

Sexual differences in the shell extremely great. The general form of the male shell is ovate, somewhat pointed posteriorly, with a rather distinct posterior ridge and a radial furrow in front of it. The female shell is also ovate, but the wider part is behind, and it is not at all pointed at the posterior end, but broadly rounded. The place of the radial furrow is filled by a broad postbasal expansion, which may occupy the whole posterior half of the shell, and from the anterior part, this is marked off, in old specimens, by a more or less distinct constriction. In young females (Pl. XXI, fig. 6), this postbasal expansion is less developed, and the shell is only slightly thinner here than the rest of it. But in old females this expansion is greatly developed, and is very thin, since the deposition of nacreous matter ceases here, and thus the expansion appears chiefly horny (epidermis), with a thin film of prismatic matter. The females grow practically to the same size as the males.

		L.	H.	D.
Size:	(Males) 1. Meadville, Cat. No. 61.3362	72 mm.	50 mm.	31 mm.
	2. Cochranton, Cat. No. 61.3363	70 "	50 "	33 "
	3. do. " " do.	61 "	46 "	29 "
	4. do. " " do.	45 "	33 "	22 "
	5. Utica, Cat. No. 61.3368	37 "	28 "	19 "
	(Females) 6. Warren, Cat. No. 61.3979	70 "	45 "	32 "
	7. Cochranton, Cat. No. 61.3363 (gravid)	65 "	43 "	30 "
	8. Hickory, Cat. No. 61.3366 (gravid)	62 "	42 "	25 "
	9. Cochranton, Cat. No. 61.3363	51 "	36 "	25 "
	10. Harbor Bridge, Cat. No. 61.3372	36 "	26 "	17 "

Soft parts (See Ortmann, 1912, p. 358, fig. 28). *Glochidia* (See *ibid.*) similar to those of *T. perplexa* Lea (Obs. VI, 1858, Pl. 5, fig. 21) (= *torulosa* Rafinesque).

Breeding season: Gravid females were collected on Sept. 2, 1908; Sept. 5, 1908; Sept. 6, 1908; Sept. 15, 1909; Sept. 18, 1908. On the first date young glochidia were already observed, and thus the beginning of the season probably falls early in August. The species probably is *bradytictic.*

Remarks: T. rangiana has been considered a variety of *T. torulosa* (Rafinesque) = *perplexa* Lea. The latter is not found in Pennsylvania. It is dis-

tinguished from *T. rangiana* by the presence of a radial row of tubercles upon the middle of the shell, standing in the male upon the radial rib, in the female in front of the marsupial expansion; and further *T. torulosa* has the postbasal expansion of the female dark green in color.

Slightly tuberculate specimens once existed in Pennsylvania, and I collected such in an Indian Garbage heap at Point Marion (Ortmann, 1909*c*). I have called them *T. cincinnatiensis*, but they are not the true *cincinnatiensis*, and are by no means the typical *T. torulosa*. Whether forms approaching the latter once existed in the Monongahela and Ohio cannot be now ascertained. All *living* shells from Pennsylvania are typical *rangiana*. Some specimens, indeed, show indications of tubercles, but these are rather indefinite, obscure swellings, the majority of the specimens being perfectly smooth.

The female of this species is easily recognized by the peculiar postbasal expansion. The male, however, has a shape which reminds of young *Plethobasus cyphyus*. But *P. cyphyus* has a lighter yellow epidermis, and has no rays. Moreover the beak-sculpture is quite different.

The range of variation has been already indicated in the description. Disregarding the slight tendency to show traces of tubercles in the middle of the shell, the radial furrow is somewhat variable, and also the angle in the middle of the lower margin. The postbasal expansion of the female is very variable, increasing with the age of the individual, but it always is of light color, not dark-green.

Localities in Pennsylvania represented in the Carnegie Museum:

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.
Allegheny River, Aladdin, Godfrey, Johnetta, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.
French Creek, Utica, Venango Co.; Cochranton and Meadville, Crawford Co.
Connewango Creek, Russell, Warren Co.

Other localities represented in the Carnegie Museum:

West Fork River, Lynch Mines, Harrison Co., West Virginia.
Tuscarawas River, Ohio (Holland collection).
Columbus, Franklin Co., Ohio (Hartman collection) (Smith collection).
White River, Rockford, Jackson Co., Indiana (G. H. Clapp, donor) (Wabash-drainage).

Distribution and Ecology in Pennsylvania (See fig. 34): I have found this species in the Beaver-drainage in the Shenango River,[213a] where it is very rare

[213a] I have not seen it in the Mahoning River in Pennsylvania, although it has been reported from this river in Ohio (Lea, 1838; Dean, 1890).

(only three specimens taken), and in the Allegheny River from Armstrong County up to Warren County. It is also found in French and Connewango Creeks, tributaries of the Allegheny. In the Allegheny itself it is found rather regularly, but not in great numbers; it is most abundant in French Creek and at Cochranton it was a common species.

In the Monongahela-drainage I never found it alive, but its former occurrence there is indicated by shells from the Indian garbage heap at Point Marion. It also occurs farther up in the headwaters in West Virginia, but is very rare.

It is remarkable that this species has not turned up in the Ohio below Pittsburgh, and that there are no localities for it positively ascertained in the Ohio, until we reach Cincinnati.

I always found this species on riffles, perferably upon a bottom composed of firmly packed and rather fine gravel, in swiftly flowing, shallow water. In the Allegheny in Armstrong County I have also seen it in coarse gravel.

General distribution: Type locality, Ohio River, Cincinnati (Lea).

Aside from western Pennsylvania and the upper Monongahela in West Virginia, this species is known from the state of Ohio. In the Ohio proper only the type locality is known; but according to Sterki (1907*a*) it is found in the Mahoning, Tuscarawas, and Scioto Rivers. In Indiana it is found in the Ohio and Wabash (Call, 1896*a*), and in White River (Carnegie Museum) and in Illinois only in the southern portion (Wabash, see Baker, 1906). In addition it occurs in southeastern Michigan, in the Lake Erie-drainage (Detroit and Raisin Rivers, see Walker, 1892 & 1898), and it is also given (Walker, 1913) in the Lake Erie list, but has never been found on the Pennsylvanian shores of the lake.

According to these records, this species is rather restricted in its range, and belongs to the Ohio River and its tributaries, chiefly the northern ones, and seems to have its metropolis in the smaller tributaries of the upper Ohio River in the states of Ohio and Pennsylvania. It also has crossed over into the lake-drainage, but particulars are lacking.

An allied species is *T. torulosa* (= *perplexa*), which seems to inhabit the lower Ohio and the Tennessee drainage. It is interesting to note that the latter develops in the upper Tennessee a compressed form without tubercles, which should be called *gubernaculum* Reeve, and which is a form parallel to *rangiana*, but has the dark green postbasal expansion of *torulosa*. This case should be kept in mind, for it is an interesting instance of the reactions of the Naiades to environmental conditions. The form most closely related to *T. rangiana* undoubtedly is *T. sampsoni* (Lea) of the lower Wabash, which differs only in having the shell more

swollen and the beaks more inflated. It possibly is only the big-river-form of *T. rangiana*.

BIBLIOGRAPHY.

1842 Adams, C. B. Freshwater and Land Shells of Vermont (In Thompson, Z., *History of Vermont*, I, 1842, p. 164).

1869 Aldrich, T. H. Partial list of shells from near Troy, New York. (*Twenty-second Report of the University of New York*, 1869, pp. 17–24.)

1898*a* Baker, F. C. The Mollusca of the Chicago Area. Pelecypoda. (*Bulletin Chicago Academy of Science*, 1898, pp. 46–110.)

1898*b* Baker, F. C. The Molluscan Fauna of Western New York. (*Proceedings Academy Science St. Louis*, VIII, 1898, p. 71.)

1906 Baker, F. C. A Catalogue of the Mollusca of Illinois (*Bulletin Illinois State Laboratory*, VII, 1906, pp. 53–135).

1914 Baker, F. C. Mollusks from Magician Lake, Cass and Van Buren Counties, Michigan (*Nautilus*, XXVIII, 1914, pp. 8–10).

1823 Barnes, D. W. On the Genera Unio and Alasmodonta, with Introductory Remarks (*American Journal of Science*, VI, 1823, pp. 107–127; 258–280).

1859 Bell, R. Notes on the Natural History of the Gulf of St. Lawrence, and the Distribution of the Mollusca (*Canadian Naturalist and Geologist*, IV, 1859, p. 219).

1858 Binney, W. G. The Complete Writings of Thomas Say on the Conchology of the United States. 1858.

Binney, W. G. (See Gould, A. A.)

1903 Blatchley, W. S. & Daniels, L. E. On some Mollusca Known to Occur in Indiana (*26th Annual Report Indiana Department Geology and Natural Resources for 1901* (1903), pp. 577–628).

1869 Bruckhart, H. G. Conchology (In Mombert, J. I., *An Authentic History of Lancaster County*, 1869, pp. 517–518).

1911 Caffrey, G. W. The Molluscan Fauna of Northampton County, Pennsylvania (*Nautilus*, XXV, 1911, pp. 26–29.)

1878 Call, R. E. Mode of Distribution of Freshwater Mussels (*American Naturalist*, XII, 1878, p. 472).

1885 Call, R. E. A Geographical Catalogue of the Unionidæ of the Mississippi Valley (*Bulletin Des Moines Academy of Science*, I, 1885, pp. 5, *et seq.*).

1895 Call, R. E. A Study of the Unionidæ of Arkansas, with Incidental Reference to their Distribution in the Mississippi Valley (*Transactions Academy of Sciences, St. Louis*, VII, 1895, pp. 1–64).

1896*a* Call, R. E. Unionidæ of Indiana, according to Hydrographic Basins (*Proceedings Indiana Academy*, 1896, pp. 251, *ff.*).

1896*b* Call, R. E. Illustrations of Little-known Unionidæ (*Journal Cincinnati Society Natural History*, XVIII, 1896, pp. 157–160).

1900 Call, R. E. A Descriptive Illustrated Catalogue of the Mollusca of Indiana (*24th Annual Report Indiana Department Geology and Natural Resources for 1899* (1900), pp. 335–535).

1910 Carl, S. Die Flussperlmuschel und ihre Perlen. Karlsruhe. 1910.

1890 Carpenter, H. F. Shell-bearing Mollusks of Rhode Island (*Nautilus*, IV, 1890, p. 22).

1855 Christy, R. M. Notes on the Land and Freshwater Mollusks of Manitoba (*Journal Conchology*, IV, 1855, pp. 339–349).

1895 Clapp, G. H. Mollusks of Allegheny County, Pennsylvania (*Nautilus*, VIII, 1895, p. 116).

Clark, H. W. (See Wilson & Clark and Meek & Clark.)

1911 Coker, R. E. & Surber, T. A Note on the Metamorphosis of the Mussel *Lampsilis lævissimus* (*Biological Bulletin*, XX, 1911, pp. 179–182).

1904 Conner, C. H. *Margaritana margaritifera* in Pennsylvania (*Nautilus*, XVIII, 1904. p. 91).

1907 Conner, C. H. The Gravid Periods of Unios (*Nautilus*, XXI, 1907, pp. 87–89).

1909 Conner, C. H. Supplementary Notes on the Breeding Seasons of the Unionidæ (*Nautilus*, XXII, 1909, pp. 111–112).

1834 Conrad, T. A. New Fresh-water Shells of the United States. Philadelphia. 1834.

1835–1840 Conrad, T. A. Monography of the Family Unionidæ of North America. Philadelphia, 1835–1840.

1846 Conrad, T. A. Notices of Fresh-water Shells, etc., of Rockbridge County, Virginia (*American Journal of Science* (2), I, 1846, pp. 405–407).

1856 Conrad, T. A. On a New Species of Unio (*American Journal of Science* (2), XXI, 1856, p. 172).

Coolidge, W. H. (See Walker & Coolidge.)

1855 Cooper, W. Appendix No. 2 (In Schoolcraft, H. R., *Narrative of an Expedition to the Sources of the Mississippi River*, 1855, pp. 515–518).

Curtis, W. C. (See Lefevre & Curtis.)

1895 Dall, W. H. & Simpson, C. T. (In Kirsch, P. H., Report on the Invertebrates of the Maumee River Basin (*Bulletin U. S. Fish Commission* for 1894 (publ. 1895), p. 332)).

Daniels, L. E. (See Blatchley & Daniels.)

1875 Dawson, G. M. Land and Fresh-water Mollusca Collected During the Summer of 1873–1874 in the Vicinity of the Forty-ninth Parallel, Lake of the Woods to the Rocky Mountains (*British North American Boundary Commission, Report on Geology*, 1875, pp. 347–350).

1890 Dean, G. W. Distribution of Unionidæ in the Mahoning, Cuyahoga, and Tuscarawas Rivers (*Nautilus*, IV, 1890, p. 21 *et seq.*).

1891 Dean, G. W. On the Distinguishing Characters of *Unio radiatus* and *Unio luteolus* (*Nautilus*, V, 1891, pp. 77–78).

1843 DeKay, J. E. Natural History of New York, Part V, Mollusca, 1843.

1856 Dewey, C. List of Naiades found in Western New York (*Ninth Annual Report of the Regents of the University of New York*, 1856, pp. 32–38).

1835 Earle, J. M. List of Land and Fresh-water Shells in Massachusetts (In Hitchcock, E., *Report on the Geology, Mineralogy, Botany and Zoötogy of Massachusetts*, 1835, pp. 22–23).

1913 Forbes, S. A. & Richardson, R. E. Studies on the Biology of Upper Illinois River (*Bulletin Illinois State Laboratory of Natural History*, IX, 1913, pp. 481–574).

1901 Fox, W. J. The Locality of Say's Type of *Alasmidonta marginata* (*Nautilus*, XV, 1901, p. 47).

1899 Frierson, L. S. Unionidæ of De Soto Parish, Louisiana (*The Gulf Fauna and Flora, Bulletin* I, 1899, pp. 6 *et seq.*).

1911 Frierson, L. S. Remarks on *Unio varicosus, cicatricosus*, and *Unio compertus*, new species (*Nautilus*, XXV, 1911, pp. 51–54).

1914*a* Frierson, L. S. Remarks on Classification of the Unionidæ (*Nautilus*, XXVIII, 1914, pp. 6–8).

1914*b* Frierson, L. S. Observations on the Genus *Symphynota Lea* (*Nautilus*, XXVIII, 1914, p. 40).

1915 Frierson, L. S. Lasmigona subviridis Conrad, Redivivus (*Nautilus*, XXIX, 1915, pp. 57–59).

1917 Frierson, L. S. New Genera and Species of Central American Naiades (*Nautilus*, XXXI, 1917, pp. 47–49).

1861 Gabb, W. M. List of Mollusks Inhabiting the Neighborhood of Philadelphia (*Proceedings Academy Natural Sciences of Philadelphia*, 1861, pp. 306–310).

1910 Geiser, S. W. Notes on the Naiad Fauna of Northeastern Iowa (*American Midland Naturalist*, I, 1910, pp. 229–233).

1914 Goodrich, C. Unios of the Wabash and Maumee Drainage Systems (*Nautilus*, XXVII, 1914, pp. 131–132).

1870 Gould, A. A. Report on the Invertebrates of Massachusetts. 2d ed. by W. G. Binney, 1870.

1886 Grant, U. S. Conchological Notes (*14th Annual Report of the Geological and Natural History Survey of Minnesota for 1885* (1886), p. 114 *et seq.*).

1883 Gray, A. F. On the Eastern Range of *Unio pressus* (*American Naturalist*, XVII, 1883, p. 204).

1827 Green, J. Some Remarks on the Unios of the United States, with a Description of a New Species (*Contributions of the Maclurian Lyceum to the Arts and Sciences*, I, 1827, pp. 41–47).

1918 Grier, N. M. New Varieties of Naiades from Lake Erie. (*Nautilus*, XXXII, 1918, pp. 9–12.)

1910 Haas, F. On *Unio, Margaritana, Pseudanodonta,* and their occurrence in the Thames Valley (*Proceedings Malacological Society of London*, IX, 1910, pp. 106–112).

1913 Haas, F. Bemerkungen über Spenglers Unionen (*Vidensk. Meddel. Dansk. Naturh. Foren. Kbhvn.*, LXV, 1913, pp. 51–66).

1844 Haldeman, S. S. Mollusca (In Rupp's *History of Lancaster County*, 1844, p. 479).

1899 Hanham, A. W. A List of the Land and Fresh-water Shells of Manitoba (*Nautilus*, XIII, 1899, p. 1, *et seq.*).

1907 Harms, W. Zur Biologie und Entwicklungsgeschichte der Flussperlmuschel (*Zoölog. Anzeiger*, XXXI, 1907, pp. 814–824).

1891 Harn, E. H. Western Pennsylvania Shells (*Nautilus*, IV, 1891, pp. 136–137).

1896 Harper, G. W. Catalogue of the Shells in the Vicinity of Cincinnati (*Journal Cincinnati Society of Natural History*, XVIII, 1896, p. 89).

1874 Hartman, W. D. & Michener, E. Conchologia Cestrica. Philadelphia, 1874.

1906 Headlee, T. J. Ecological Notes on the Mussels of Winona, Pike, and Center Lakes of Kosciusko County, Indiana (*Biological Bulletin*, XI, 1906, p. 305 *et seq.*).

1828 Hildreth, S. P. Observations on and Description of the Shells Found in the Muskingum River (*American Journal Science*, XIV, 1828, pp. 276–291).

1888 Holzinger, J. M. Mollusca of Winona County (Minnesota) (*Sixteenth Annual Report of the Geological and Natural History Survey of Minnesota for 1887* (published 1888), pp. 481 *et seq.*).

1914 Howard, A. D. Experiments in Propagation of Fresh-water Mussels of the *Quadrula* Group (*U. S. Bureau of Fisheries, Doc. No. 801*, 1914, pp. 1–52).

1901 Ihering, H. von. The Unionidæ of North America (*Nautilus*, XV, 1901, pp. 37–39, 50–53).

1910 Israël, W. Beiträge zur Kenntnis der Fauna der weissen Elster (*Nachr. Bl. deutsch. Malkozoöl. Ges.*, 1910, pp. 173–181).

1908 Jackson, H., Jr. The Mollusca of North Haven, Maine (*Nautilus*, XXI, 1908, pp. 142–144).

1915 Johnson, C. W. Fauna of New England, XIII, List of the Mollusca (*Occasional Papers of the Boston Society of Natural History*, VII, 1915, pp. 1–231).

1888 Keyes, C. R. An Annotated Catalogue of the Mollusca of Iowa (*Bulletin of the Essex Institute*, XX, 1888, pp. 61–83).

1815–1822 Lamarck, J. B. Histoire Naturelle des Animaux sans Vertèbres. 1815–1822. (I quote from the 2d Ed., by Deshayes, G. P., & Milne-Edwards, H., vol. VI, 1835.)

1860 LAPHAM, J. A. List of the Shells of Wisconsin (*Proceedings Academy of Natural Sciences of Philadelphia*, 1860, p. 154, *et seq.*).

1914 LATCHFORD, F. R. *Valvata piscinalis* in Canada (and other remarks) (*Nautilus*, XXVIII, 1914, p. 10).

1834–1874 LEA, I. Observations on the Genus *Unio*. Vols. 1–13. Philadelphia. 1834–1874.

1910 LEFÈVRE, G. & CURTIS, W. C. Reproduction and Parasitism in the Unionidæ (*Journal of Experimental Zoölogy*, IX, 1910, pp. 79–115).

1912 LEFEVRE, G. & CURTIS, W. C. Studies on the Reproduction and Artificial Propagation of the Fresh-water Mussels (*Bulletin of the Bureau of Fisheries*, XXX, for 1910 (publ. 1912), pp. 105–201).

1889 LEIDY, J. Notice and Description of Fossils in Caves and Crevices of the Limestone Rocks of Pennsylvania (*Annual Report of the Geological Survey of Pennsylvania for 1887* (publ. 1889), pp. 1–20).

1909 LERMOND, N. W. Shells of Maine (*Seventh Annual Report of the Commission of Agriculture of Maine for 1908* (1909), pp. 217–262).

1856 LEWIS, J. Mollusca in Little Lakes, Otsego County, New York (*Proceedings Academy of Natural Sciences of Philadelphia*, 1856, p. 259).

1860 LEWIS, J. Catalogue of the Mollusks in the Vicinity of Mohawk, New York (*Proceedings Academy of Natural Sciences of Philadelphia*, 1860, p. 17).

1870 LEWIS, J. Catalogue of the Shells of the Coosa River, Alabama (*American Journal of Conchology*, V, 1870, p. 167).

1871 LEWIS, J. On the Shells of the Holston River (*American Journal of Conchology*, VI, 1871, pp. 216–226).

1877 LEWIS, J. Unionidæ of Ohio and Alabama (*Proceedings Academy of Natural Sciences of Philadelphia*, 1877, p. 26, *et seq.*).

1845 LINSLEY, J. H. Catalogue of the Shells of Connecticut (*American Journal of Science*, XLVIII, 1845, pp. 271–286).

1890 MARSHALL, W. B. Beaks of Unionidæ Inhabiting the Vicinity of Albany, New York (*Bulletin New York State Museum*, II, 1890, pp. 169–189).

1895 MARSHALL, W. B. Geographical Distribution of New York Unionidæ (*Forty-eighth Annual Report New York State Museum*, 1895, pp. 47–99).

1912 MEEK, S. E. & CLARK, H. W. The Mussels of the Big Buffalo Fork of White River, Arkansas (*U. S. Bureau of Fisheries, Doc. 759*, 1912, pp. 1–20).

MICHENER, E. (See HARTMAN & MICHENER.)

1902 NORRIS, A. A. A List of the Mollusca of Eagle, Centre, and Pike Lakes, Kosciusko Co., Indiana (*Proceedings Indiana Academy of Science for 1901* (publ. 1902), pp. 118–119).

1914 NYLANDER, O. O. Distribution of Some Fresh-water Shells of the St. John's River Valley in Maine, New Brunswick, and Quebec (*Nautilus*, XXVII, 1914, pp. 139–141).

1909*a* Ortmann, A. E. The Breeding Season of Unionidæ in Pennsylvania (*Nautilus*, XXII, 1909, pp. 91–95; 99–103).

1909*b* Ortmann, A. E. A preliminary List of the Unionidæ of Western Pennsylvania, with New Localities for Species from Eastern Pennsylvania (*Annals Carnegie Museum*, V, 1909, pp. 178–210).

1909*c* Ortmann, A. E. Unionidæ from an Indian Garbage Heap (*Nautilus*, XXIII, 1909, pp. 11–15).

1910 Ortmann, A. E. A New System of the Unionidæ (*Nautilus*, XXIII, 1910, pp. 114–120).

1911*a* Ortmann, A. E. The Anatomical Structure of Certain Exotic Najades compared with that of the North American Forms (*Nautilus*, XXIV, 1911, pp. 103–108; 114–120; 127–131).

1911*b* Ortmann, A. E. Monograph of the Najades of Pennsylvania (*Memoirs Carnegie Museum*, IV, 1911, pp. 279–347).

1912 Ortmann, A. E. Notes upon the Families and Genera of the Najades (*Annals Carnegie Museum*, VIII, 1912, pp. 222–365).

1913*a* Ortmann, A. E. The Alleghenian Divide, and its Influence upon the Freshwater Fauna (*Proceedings American Philosophical Society*, LII, 1913, pp. 287–390).

1913*b* Ortmann, A. E. Studies in Najades (*Nautilus*, XXVII, 1913, pp. 88–91).

1914 Ortmann, A. E. Studies in Najades (*Nautilus*, XXVIII, 1914, pp. 41–47; 65–69; 129–131).

1869 Perkins, G. H. Molluscan Fauna of New Haven (*Proceedings Boston Society of Natural History*, 1869, p. 154).

1894 Pilsbry, H. A. Critical List of Mollusks Collected in the Potomac Valley (*Proceedings Academy of Natural Sciences of Philadelphia*, 1894, pp. 11–30).

1901 Pilsbry, H. A. *Alasmidonta marginata* (Say) (*Nautilus*, XV, 1901, pp. 16–17).

1876 Pratt, W. H. List of Shells at Davenport, Iowa (*Proceedings Davenport Academy Natural Sciences*, I, 1876, pp. 165–167).

1820 Rafinesque, C. S. Monographie des Coquilles Bivalves et Fluviatiles de la Rivière Ohio (*Annales Générales des Sciences Physiques*, Bruxelles, V, 1820) (Reprinted 1912, by the University of Notre Dame, Indiana).

1864–1870 Reeve, L. A. Conchologia Iconica, XVI, Unio, 1864–1868; XVII, Anodonta, 1867–1870 (continued by Sowerby, G. B.).

1899 Rhoads, S. N. On a Recent Collection of Pennsylvania Mollusks from the Ohio River System below Pittsburgh (*Nautilus*, XII, 1899, pp. 133–137).

1904 Rhoads, S. N. A Glimpse at the Shell Fauna of Delaware (*Nautilus*, XVIII, 1904, pp. 63–67).

Richardson, R. E. (See Forbes & Richardson.)

190* Ruthven, A. G. Notes on the Molluscs, Reptiles, and Amphibians of Ontonagon County, Michigan (*Sixth Annual Report of the Michigan Academy of Science*, p. 191).

Say, T. (See Binney, W. G.)

1906 Scammon, R. E. The Unionidæ of Kansas (*Kansas University Bulletins*, III, 1906, pp. 279–373).

1912 Scharff, R. F. Distribution and Origin of Life in America. New York. 1912.

1895 Schick, M. Mollusk Fauna of Philadelphia and Environs (*Nautilus*, VIII, 1895, pp. 133–140).

1891 Simpson, C. T. Notes on Unionidæ (*Nautilus*, V, 1891, pp. 86–88).

1893 Simpson, C. T. On Some Fossil Unios and Other Shells from the Drift at Toronto (*Proceedings U. S. National Museum*, XVI, 1893, pp. 591–595).

1895 Simpson, C. T. *Unio ochraceus* and *cariosus* (*Nautilus*, VIII, 1895, pp. 121–123).

1900 Simpson, C. T. Synopsis of the Naiades, or Pearly Fresh-water Mussels (*Proceedings U. S. National Museum*, XXII, 1900, pp. 501–1044).

1914 Simpson, C. T. A Descriptive Catalogue of the Naiades, or Pearly Fresh-water Mussels, Detroit, 1914.

Simpson, C. T. (See Dall & Simpson.)

1893 Singley, J. A. Texas Molluscs (*Fourth Annual Report of the Geological Survey of Texas for 1892* (1893), p. 316).

1899 Smith, H. M. The Mussel Fishery and Pearl-button Industry of the Mississippi River (*Bulletin U. S. Fish Commission*, XVIII, for 1898 (publ. 1899), pp. 289–314).

Sowerby, G. B. (See Reeve, L. A.)

1898 Sterki, V. Some Observations on the Genital Organs of the Unionidæ, with Reference to Classification (*Nautilus*, XII, 1898, pp. 18–32).

1907*a* Sterki, V. A Preliminary Catalogue of the Land and Fresh-water Mollusca of Ohio (*Proceedings of the Ohio State Academy of Sciences*, IV, 1907, pp. 367–402).

1907*b* Sterki, V. Note on Tritogonia tuberculata (*Nautilus*, XXI, 1907, p. 48).

1894 Stupakoff, S. H. Land and Fresh-water Shells of Allegheny County, Pennsylvania (*Nautilus*, VII, 1894, pp. 135–136).

1912 Surber, T. Identification of the Glochidia of Fresh-water Mussels (*U. S. Bureau of Fisheries, Doc. 771*, 1912, pp. 1–10).

1915 Surber, T. Identification of the Glochidia of Fresh-water Mussels (*U. S. Bureau of Fisheries, Doc. 813*, 1915, pp. 1–9).

Surber, T. (See Coker & Surber.)

* Separate copy, without date, but published after 1903.

1868 Tryon, G. W. Notes on Mollusca Collected by F. V. Hayden in Nebraska (*American Journal Conchology*, VI, 1868, pp. 150–151).

1916 Utterback, W. I. The Naiades of Missouri (*American Midland Naturalist*, IV, 1916, pp. 1–200).

1910 Vanatta, E. G. Unionidæ from Southeastern Arkansas and N. E. Louisiana (*Nautilus*, XXIII, 1910, pp. 102–104).

1915 Vanatta, E. G. Rafinesque's Types of Unio (*Proceedings Academy of Natural Sciences of Philadelphia*, 1915, pp. 549–559).

1893 Vaughan, T. W. Notes on Mollusks from Northwestern Louisiana and Harrison County, Texas (*American Naturalist*, XXVIII, 1893, pp. 944–961).

1892 Walker, B. The Shell-bearing Mollusca of Michigan (*Nautilus*, VI, 1892, p. 42 *et seq.*).

1894 Walker, B. Shells of Saginaw Valley, Michigan (*Nautilus*, VII, 1894, pp. 125–129).

1898 Walker, B. The Distribution of the Unionidæ in Michigan (*Report of Michigan Academy of Science, 1898*, pp. 1–20).

1909 Walker, B. Annotated List of the Mollusca of Isle Royale, Michigan (In Adams, C. C., An Ecological Survey of Isle Royale, Lake Superior (*Report University of Michigan Museum, 1909*, pp. 281–298).

1910*a* Walker, B. The Distribution of *Margaritana margaritifera* (L.) in North America (*Proceedings Malacological Society of London*, IX, 1910, pp. 126–145).

1910*b* Walker, B. On the Validity of *Unio undatus* Barnes (*Nautilus*, XXIV, 1910, pp. 6–10; 16–24).

1910*c* Walker, B. Notes on *Truncilla*, with a Key to the Species (*Nautilus*, XXIV, 1910, pp. 75–81).

1913 Walker, B. The Unione Fauna of the Great Lakes (*Nautilus*, XXVII, 1913, pp. 18–23; 29–34; 41–47; 56–59).

1915 Walker, B. *Unio viridis* Conrad. (*Nautilus*, XXIX, 1915, pp. 74–78.)

1916 Walker, B. The Rafinesque-Poulson Unios (*Nautilus*, XXX, 1916, pp. 43–47).

1918 Walker, B. Notes on North American Naiades. I. (*Occasional Papers of the Museum of Zoölogy of the University of Michigan, No. 49, 1918*, pp. 1–6.)

1908 Walker, R. D. & Coolidge, W. H., Jr. Mollusca of Keene, New Hampshire (*Nautilus*, XXII, 1908, p. 32).

1918 Wheeler, H. E. The Mollusca of Clark Co., Arkansas (*Nautilus*, XXXI, 1918, pp. 109–125).

1863 Whiteaves, J. F. On the Land and Fresh-water Mollusks of Lower Canada (*Canadian Naturalist and Geologist*, VIII, 1863, p. 99 *et seq.*)

1912*a* Wilson, C. B. & Clark, H. W. The Mussel Fauna of the Kankakee Basin (*U. S. Bureau of Fisheries, Doc. 758, 1912*, pp. 1–52).

1912*b* WILSON, C. B. & CLARK, H. W. Mussel Beds of the Cumberland River in 1911 (*U. S. Bureau of Fisheries, Economic Circular, I*, 1912, pp. 1–4).

1914 WILSON, C. B. & CLARK, H. W. The Mussels of the Cumberland River and its Tributaries (*U. S. Bureau of Fisheries, Doc. 781*, 1914, pp. 1–61).

1917 WINSLOW, M. L. An Annotated List of Shells from Northern Michigan (*Occasional Papers of the Museum of Zoölogy of the University of Michigan, No. 42, 1917*, pp. 1–16).

1878 WITTER, F. M. List of the Shells of Iowa (*Quarterly Journal of Conchology*, I, 1878, pp. 385–394).

EXPLANATION OF PLATE I.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

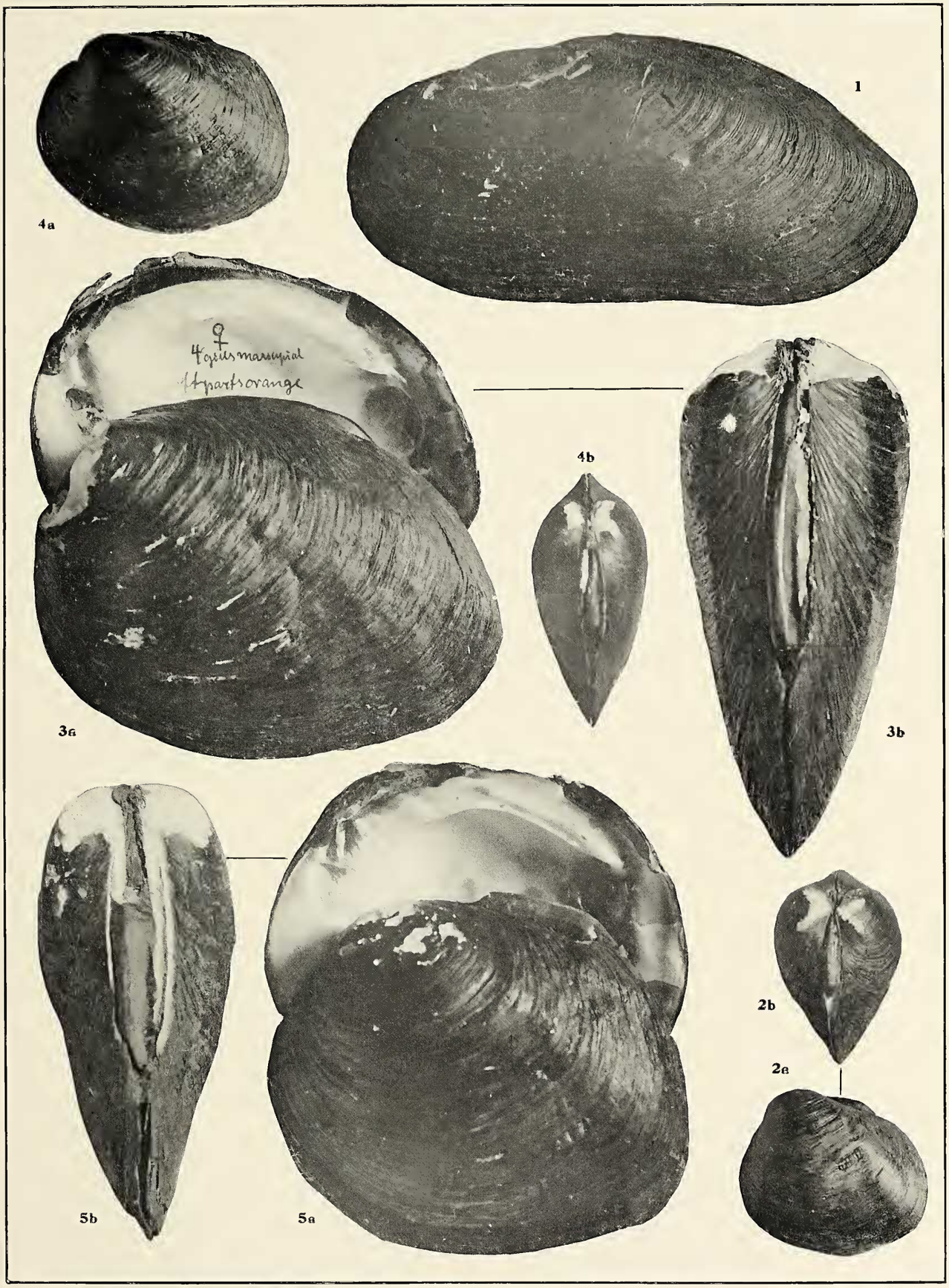
FIG. 1. *Margaritana margaritifera* (Linnæus). Normal specimen from Indian Run. Rene Mont, Schuylkill Co., Pennsylvania, collected May 4, 1909; C. M. Cat. No.61.4272,

FIG. 2. *Fusconaia subrotunda* (Lea). Young specimen of typical shape, diameter 64 per cent of length, from Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected October 5, 1908; C. M. Cat. No. 61.3941*a*.

FIG. 3. *Fusconaia subrotunda kirtlandiana* (Lea). Old female, diameter 45 per cent of length, slightly drawn out posteriorly, from Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 5, 1913; C. M. Cat. No. 61.6462.

FIG. 4. *Fusconaia subrotunda kirtlandiana* (Lea). Typical young specimen, diameter 45 per cent of length. May be regarded as a topotype, from Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected August 4, 1908; C. M. Cat. No. 61.3921.

FIG. 5. *Fusconaia subrotunda kirtlandiana* (Lea). Adult specimen representing the typical phase, diameter 42 per cent of length, also topotype from Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected October 15, 1908; C. M. Cat. No. 61.3928.



Margaritana-Fusconaia.

EXPLANATION OF PLATE II.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Fusconaia flava trigona* (Lea). Typical specimen of this form, diameter 66 per cent of length, from Monongahela River, Charleroi, Washington Co., Pennsylvania, collected by G. A. Ehrmann; C. M. Cat. No. 61.5869*b*.

Fig. 2. *Fusconaia flava parvula* Grier. Male, from the type-set, diameter 52 per cent of length, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4513.

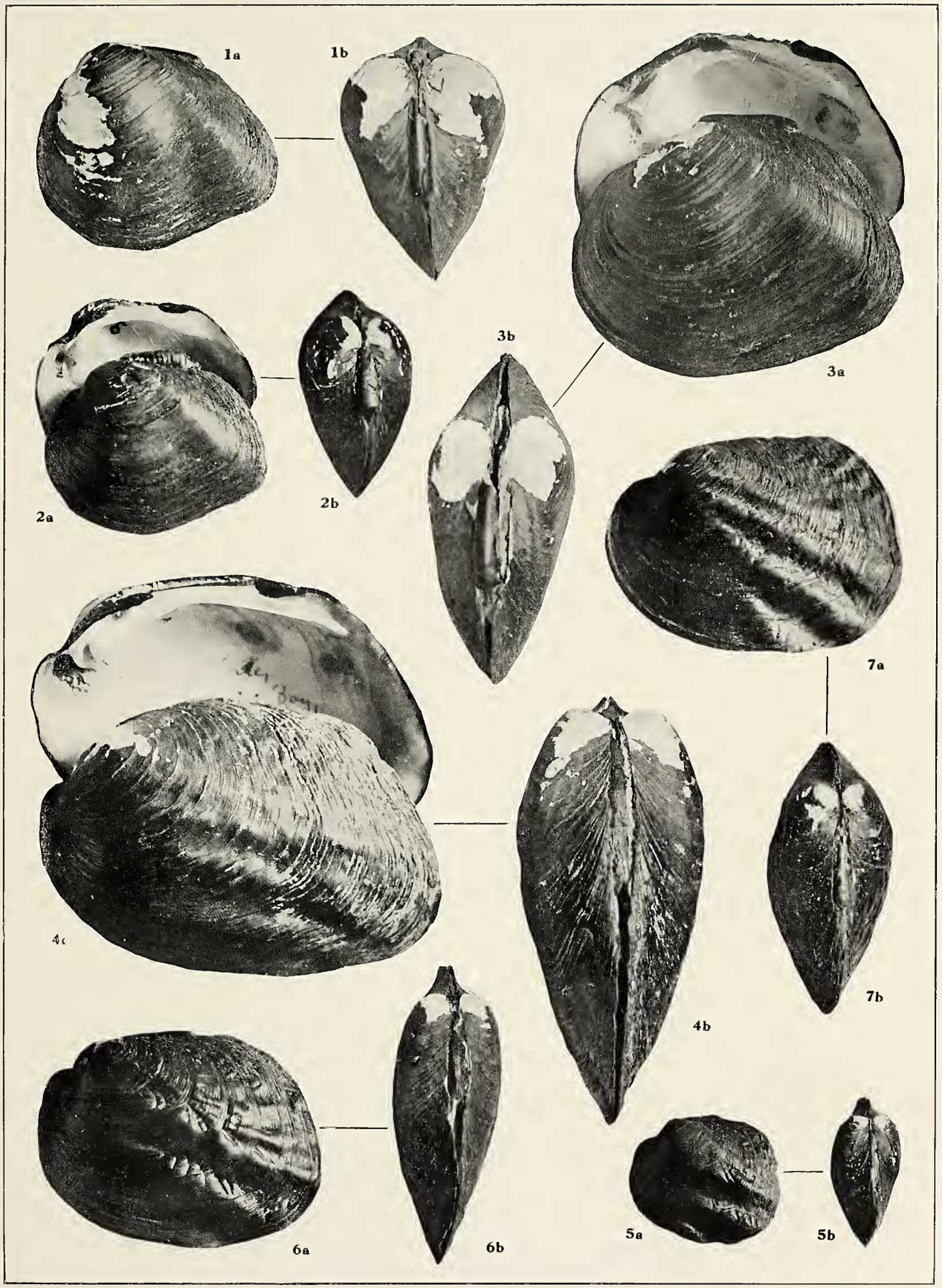
Fig. 3. *Fusconaia flava* (Rafinesque). Typical specimen, diameter 42 per cent of length, from Raccoon Creek, New Sheffield, Beaver Co., Pennsylvania, collected October 11, 1907; C. M. Cat. No. 61.3151.

Fig. 4. *Amblema plicata* (Say). Old full-grown specimen of the typical *plicata* from the type-locality, Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected June 3, 1908; C. M. Cat. No. 61.3336.

Fig. 5. *Amblema plicata* (Say). Young specimen, topotype, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4518.

Fig. 6. *Amblema plicata* (Say). Specimen of medium size, unusually compressed, topotype from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4518.

Fig. 7. *Amblema plicata costata* (Rafinesque). Rather young specimen of the much compressed form of the small creeks, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4348.



Fusconaia-Amblema.

EXPLANATION OF PLATE III.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Amblema plicata costata* (Rafinesque). Typical, gravid female, of good size, representing the compressed creek-form, from Pymatuning Creek, Pymatuning Township, Mercer Co., Pennsylvania, collected July 8, 1909; C. M. Cat. No. 61.4340.

Fig. 2. *Amblema plicata costata* (Rafinesque). Exceptional specimen, without oblique undulations, also distinctly more swollen than the normal form, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 3, 1908; C. M. Cat. No. 61.3829.

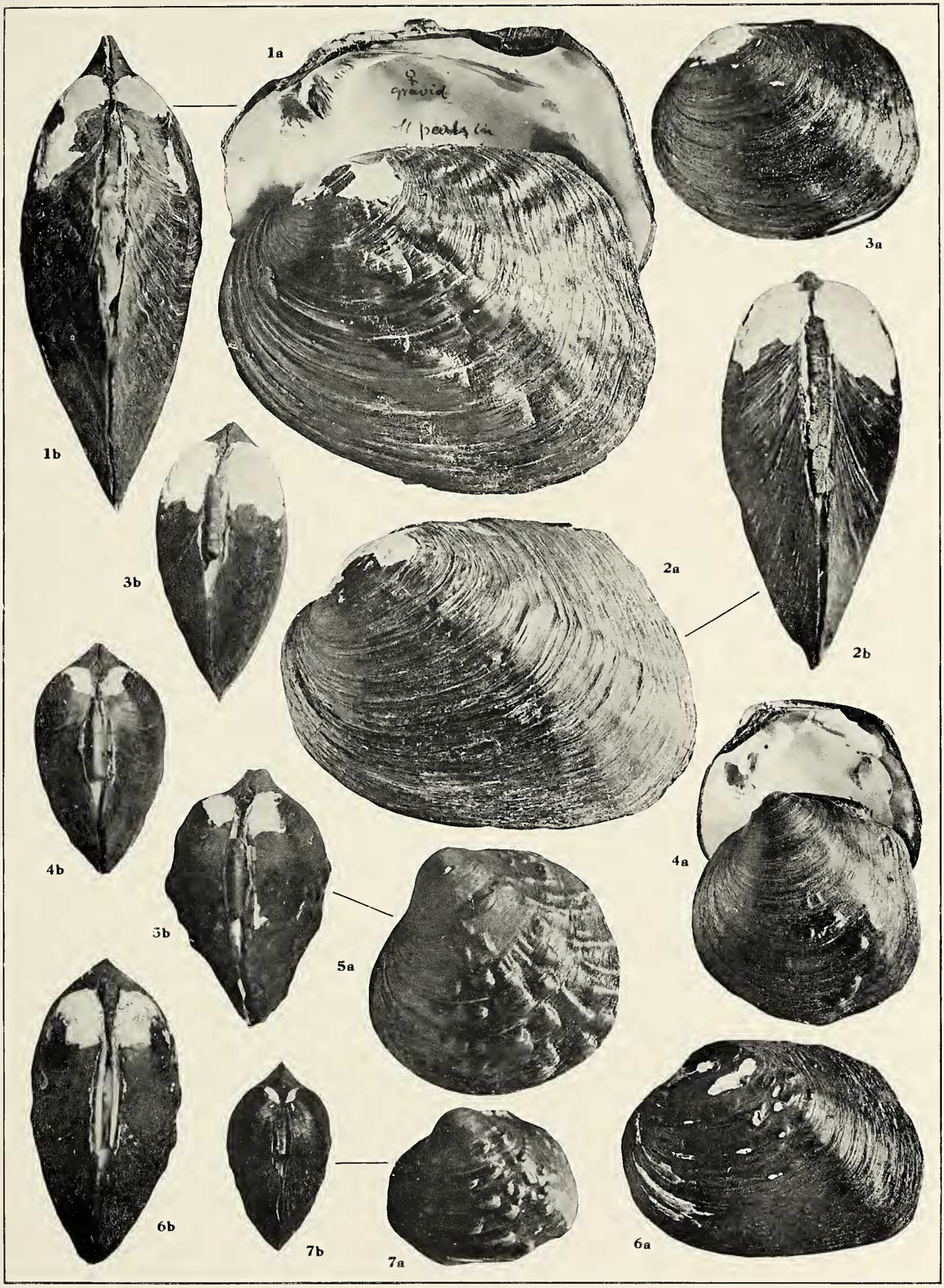
Fig. 3. *Amblema plicata costata* (Rafinesque). Young specimen with undulations nearly obliterated, also somewhat swollen, from Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected October 8, 1909; C. M. Cat. No. 61.4428.

Fig. 4. *Quadrula pustulosa* (Lea). Specimen with few tubercles, from the Mahoning River, Edinburg, Lawrence Co., Pennsylvania, collected September 15, 1908; C. M. Cat. No. 61.3875.

Fig. 5. *Quadrula pustulosa* (Lea). Specimen with numerous tubercles, from Ohio River, Industry, Beaver Co., Pennsylvania, collected October 22, 1908; C. M. Cat. No. 61.3878.

Fig. 6. *Quadrula pustulosa schoocraftensis* (Lea). Old female, unusually transverse, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4515

Fig. 7. *Quadrula pustulosa schoolcraftensis* (Lea). Female of medium size and rather normal shape, from Lake Erie, Cedar Point, Erie Co., Ohio, collected by Chas. Brookover, August 1909; C. M. Cat. No. 61.4451.



Amblema-Quadrula.

EXPLANATION OF PLATE IV.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Quadrula quadrula* (Rafinesque). Only specimen ever found in the Ohio in Pennsylvania, from Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 10, 1908; C. M. Cat. No. 61.3869.

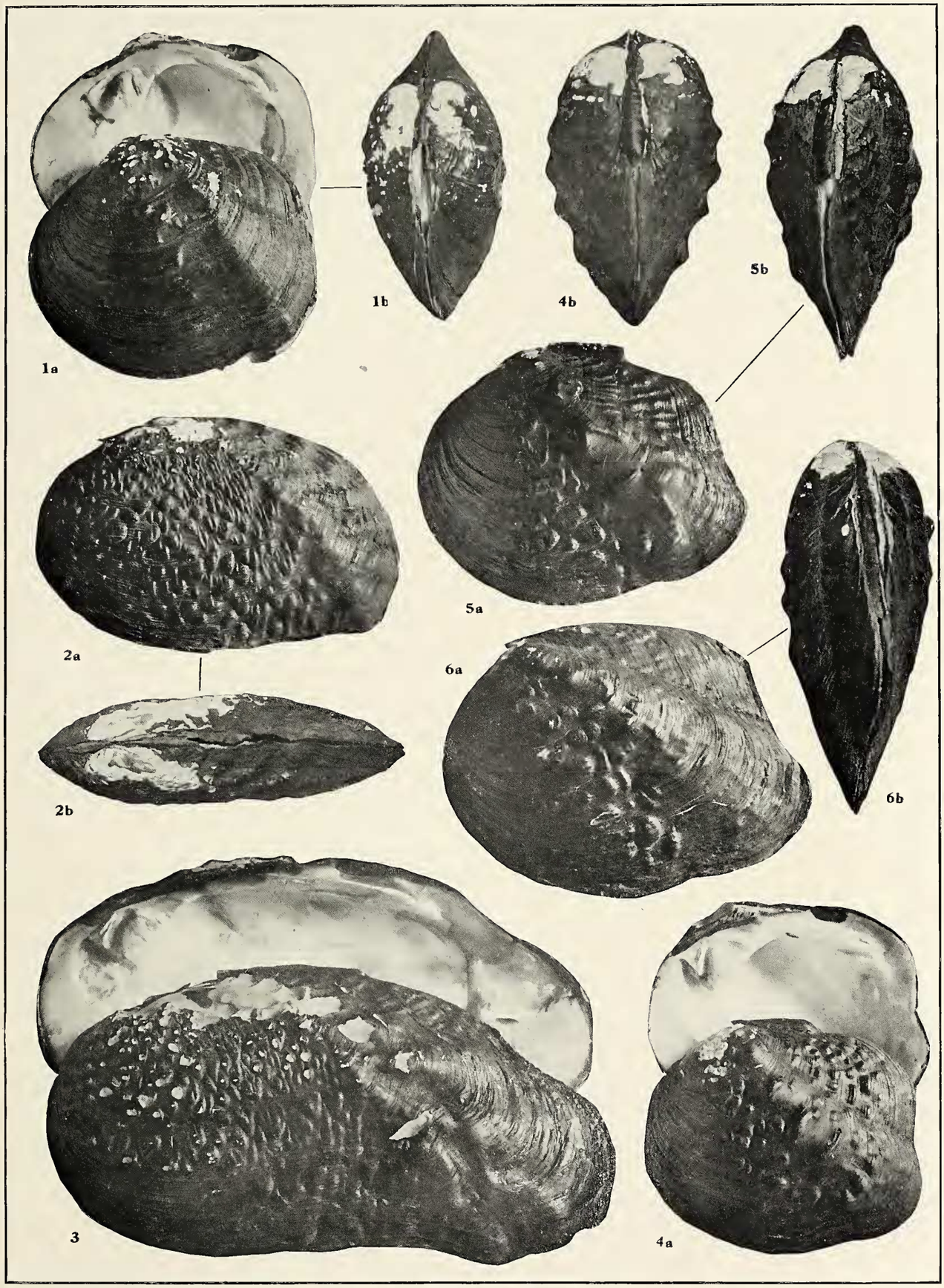
Fig. 2. *Quadrula verrucosa* (Rafinesque). Male of medium size, from Shenango River, Pulaski, Lawrence Co., Pennsylvania, collected July 19, 1909; C. M. Cat. No. 61.4121.

Fig. 3. *Quadrula verrucosa* (Rafinesque). Rather large female, from Shenango River, Pulaski, Lawrence Co., Pennsylvania, collected July 19, 1909; C. M. Cat. No. 61.4121.

Fig. 4. *Quadrula metanevra* (Rafinesque). Normal specimen from Ohio River, Industry, Beaver Co., Pennsylvania, collected September 25, 1908; C. M. Cat. No. 61.3865.

Fig. 5. *Quadrula metanevra* (Rafinesque). Specimen intergrading toward the var. *wardi* (Lea), with the tubercles moderately developed and the shell slightly more compressed, from Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3071.

Fig. 6. *Quadrula metanevra* (Rafinesque). A rather typical *wardi* (Lea), strongly compressed and with the large tubercles obliterated, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 3, 1908; C. M .Cat. No. 61.3861.



Quadrula.

EXPLANATION OF PLATE V.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Quadrula cylindrica* (Say). Normal individual, from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected August 10, 1909; C. M. Cat. No. 61.4358.

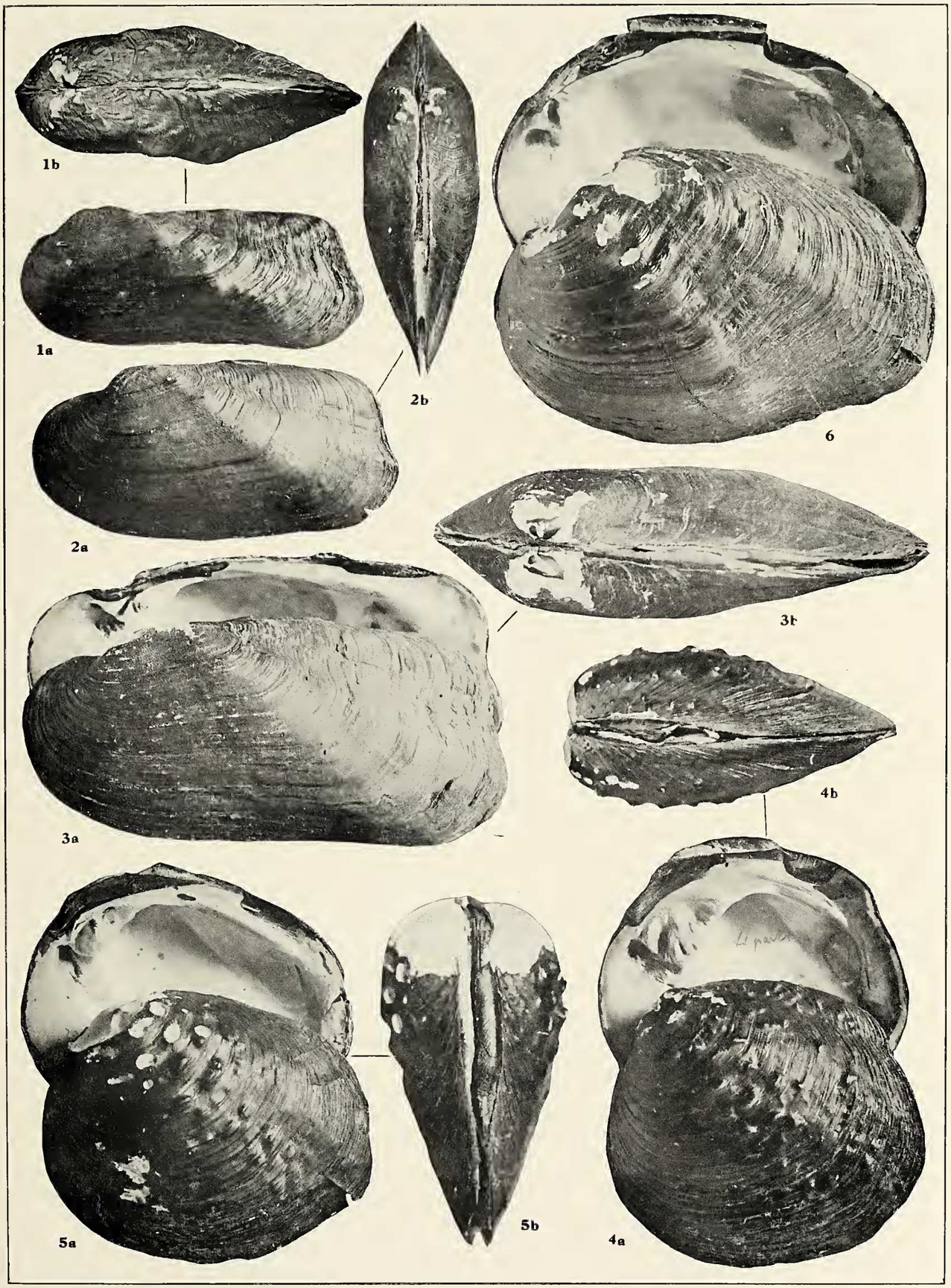
FIG. 2. *Quadrula cylindrica* (Say). Intergrade toward the smooth form, with tubercles greatly reduced, but shell not much compressed, from French Creek, Cochranton, Crawford Co., Pennsylvania, collected September 2, 1908; C. M. Cat. No. 61.3851.

FIG. 3. *Quadrula cylindrica* (Say). Smooth and compressed form, characteristic for the headwaters of the Ohio, from French Creek, Meadville, Crawford Co., Pennsylvania, collected September 1, 1908; C. M. Cat. No. 61.3850.

FIG. 4. *Rotundaria tuberculata* (Rafinesque). Female from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected August 10, 1909; C. M. Cat. No. 61.4411.

FIG. 5. *Plethobasus cooperianus* (Lea). Normal individual from the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 22, 1908; C. M. Cat. No. 61.3882.

FIG. 6. *Plethobasus cyphyus* (Rafinesque). Large specimen of normal shape, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.



Quadrula-Rotundaria-Plethobasus.

EXPLANATION OF PLATE VI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Plethobasus cyphyus* (Rafinesque). Same specimen as the one figured on Plate V, fig. 6, from the Allegheny River, Kelly Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.

FIG. 2. *Plethobasus cyphyus* (Rafinesque). Specimen of medium size, and rather short, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.

FIG. 3. *Plethobasus cyphyus* (Rafinesque). Small specimen from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.

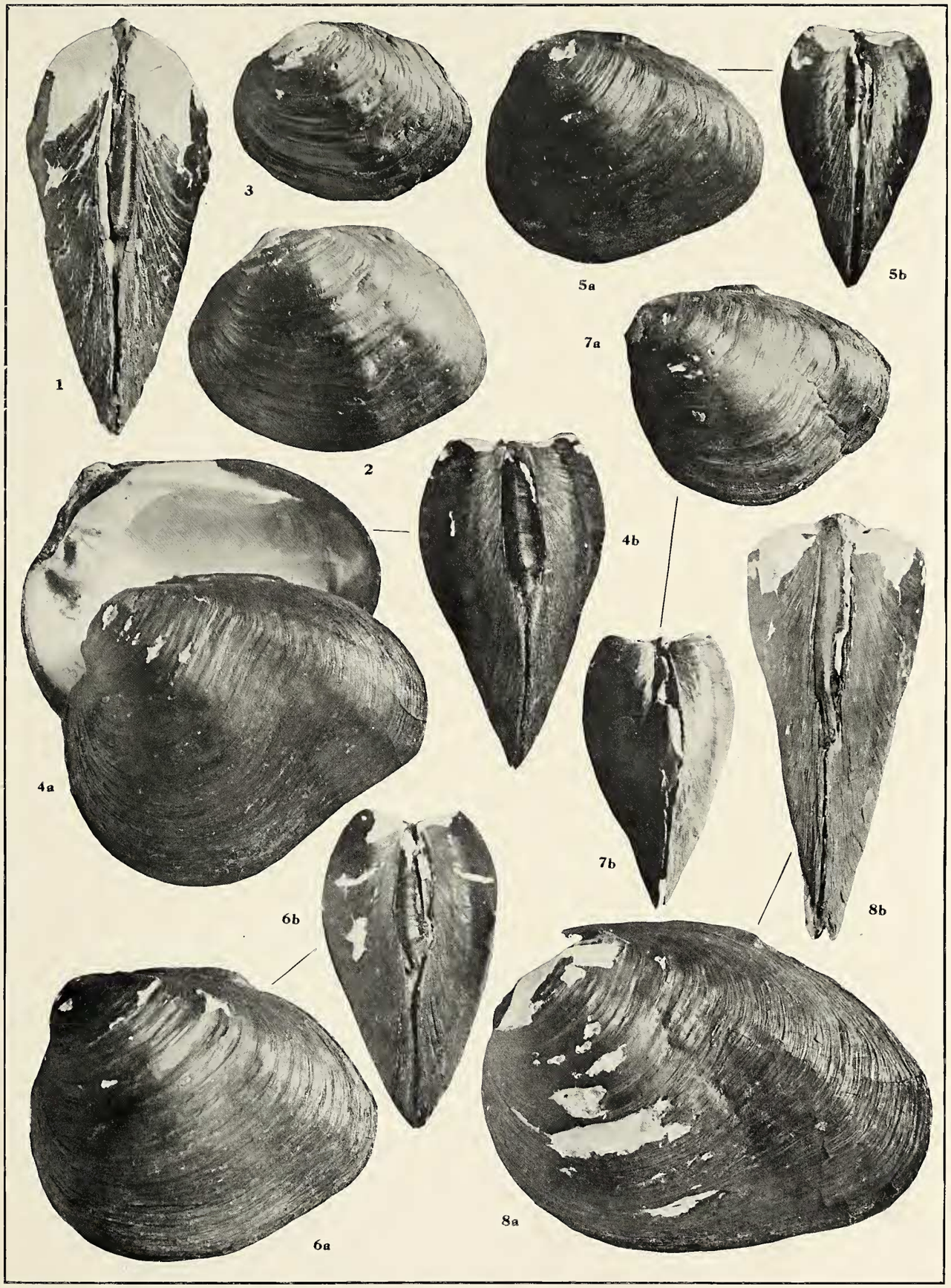
FIG. 4. *Pleurobema obliquum* (Lamarck). Normal form of the upper Ohio, diameter 55 percent of length, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 3, 1908; C. M. Cat. No. 61.3900.

FIG. 5. *Pleurobema obliquum* (Lamarck). Specimen with weak furrow, inclining toward the var. *catillus* (Conrad), diameter 57 percent of length, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 25, 1908; C. M. Cat. No. 61.3894.

FIG. 6. *Pleurobema obliquum catillus* (Conrad). A specimen closer to *catillus* than Fig. 5, diameter 56 percent of length, nacre pink. Specimens like those given in figs. 5 and 6 demonstrate that the two forms intergrade. From the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 8, 1908; C. M. Cat. No. 61.3895.

FIG. 7. *Pleurobema obliquum rubrum* (Rafinesque). Rather typical, diameter 57 percent of length, from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 13, 1908; C. M. Cat. No. 61.3891.

FIG. 8. *Pleurobema obliquum* (Lamarck). Old specimen, drawn out posteriorly and consequently with the low diameter of 42 percent of the length; when young, this was a rather typical *obliquum*. From the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 3, 1908; C. M. Cat. No. 61.3900.



Plethobasus-Pleurobema.

EXPLANATION OF PLATE VII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Pleurobema obliquum cordatum* (Rafinesque). This specimen most closely approaches this form, but is not quite typical. From the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected August 10, 1909; C. M. Cat. No. 61.4378.

Fig. 2. *Pleurobema obliquum catillus* (Conrad). Female, diameter 52 percent of length, approaching the var. *coccineum* (Conrad). From the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 27, 1910; C. M. Cat. No. 61.4567.

Fig. 3. *Pleurobema obliquum coccineum* (Conrad). Large specimen, diameter 42 percent of length, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4394.

Fig. 4. *Pleurobema obliquum coccineum* (Conrad). Younger specimen, diameter 45 percent of length, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4394.

Fig. 5. *Pleurobema obliquum coccineum* (Conrad). Topotype, diameter 46 percent of length, from Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected August 4, 1908; C. M. Cat. No. 61.3907.

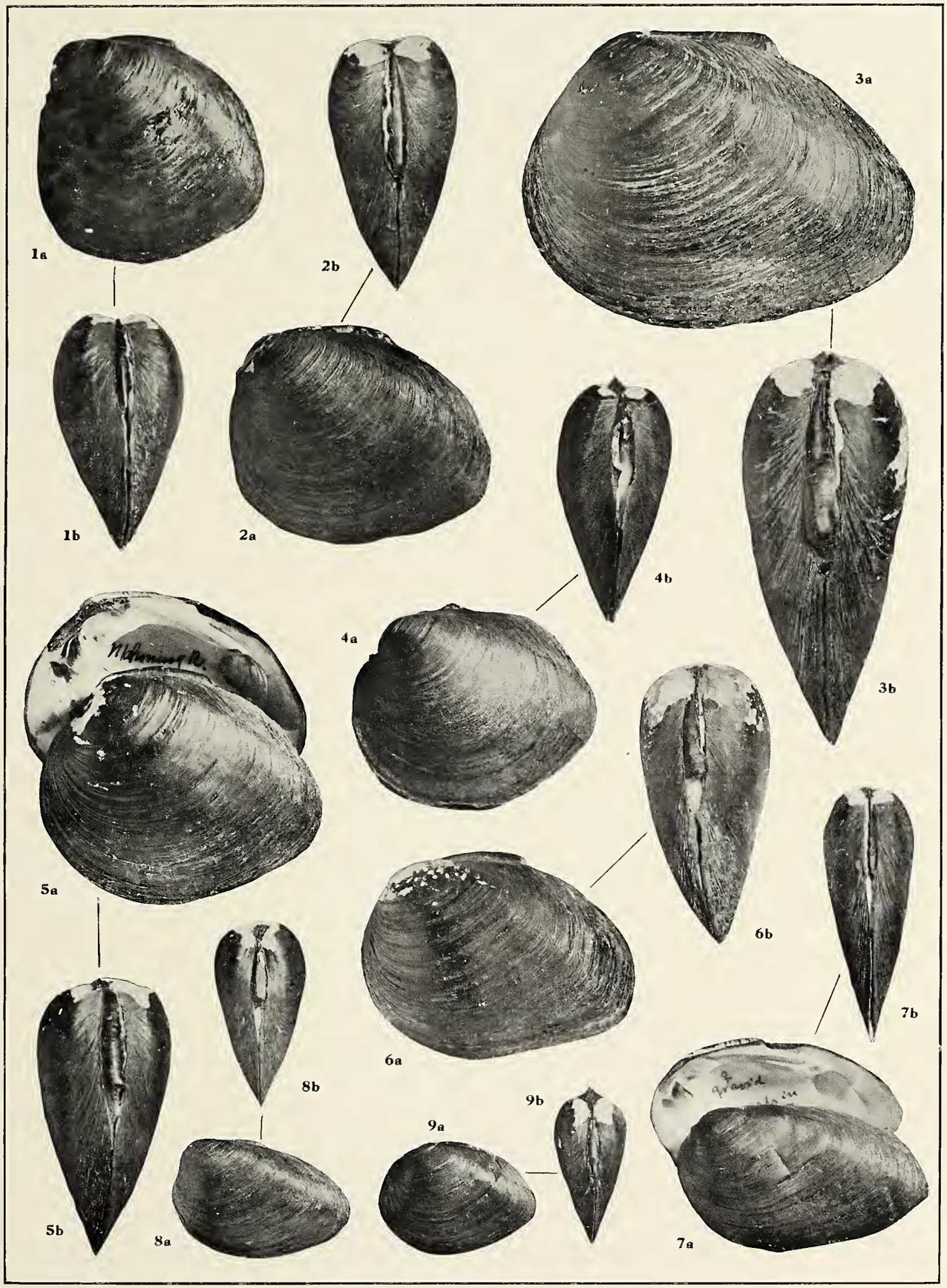
Fig. 6. *Pleurobema obliquum pauperculum* (Simpson). Typical, large specimen, diameter 47 percent of length, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 21, 1909; C. M. Cat. No. 61.4398.

Fig. 7. *Pleurobema clava* (Lamarck). Large, gravid female from Neshannock Creek, Eastbrook, Lawrence Co., Pennsylvania, collected June 18, 1908; C. M. Cat. No. 61.3335.

Fig. 8. *Pleurobema clava* (Lamarck). Smaller specimen, very oblique, from Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3814.

Fig. 9. *Pleurobema clava* (Lamarck). Small specimen, much less oblique, from Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3814.

Note: The rays and blotches present in the specimens in figs. 7, 8, and 9, did not come out in the photographs.



Pleurobema.

EXPLANATION OF PLATE VIII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Elliptio niger* (Rafinesque). Normal specimen of medium size, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 8, 1908; C. M. Cat. No. 61.3781.

FIG. 2. *Elliptio dilatatus* (Rafinesque). Gravid female of medium size, diameter 29 percent of length, from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 27, 1910; C. M. Cat. No. 61.4618.

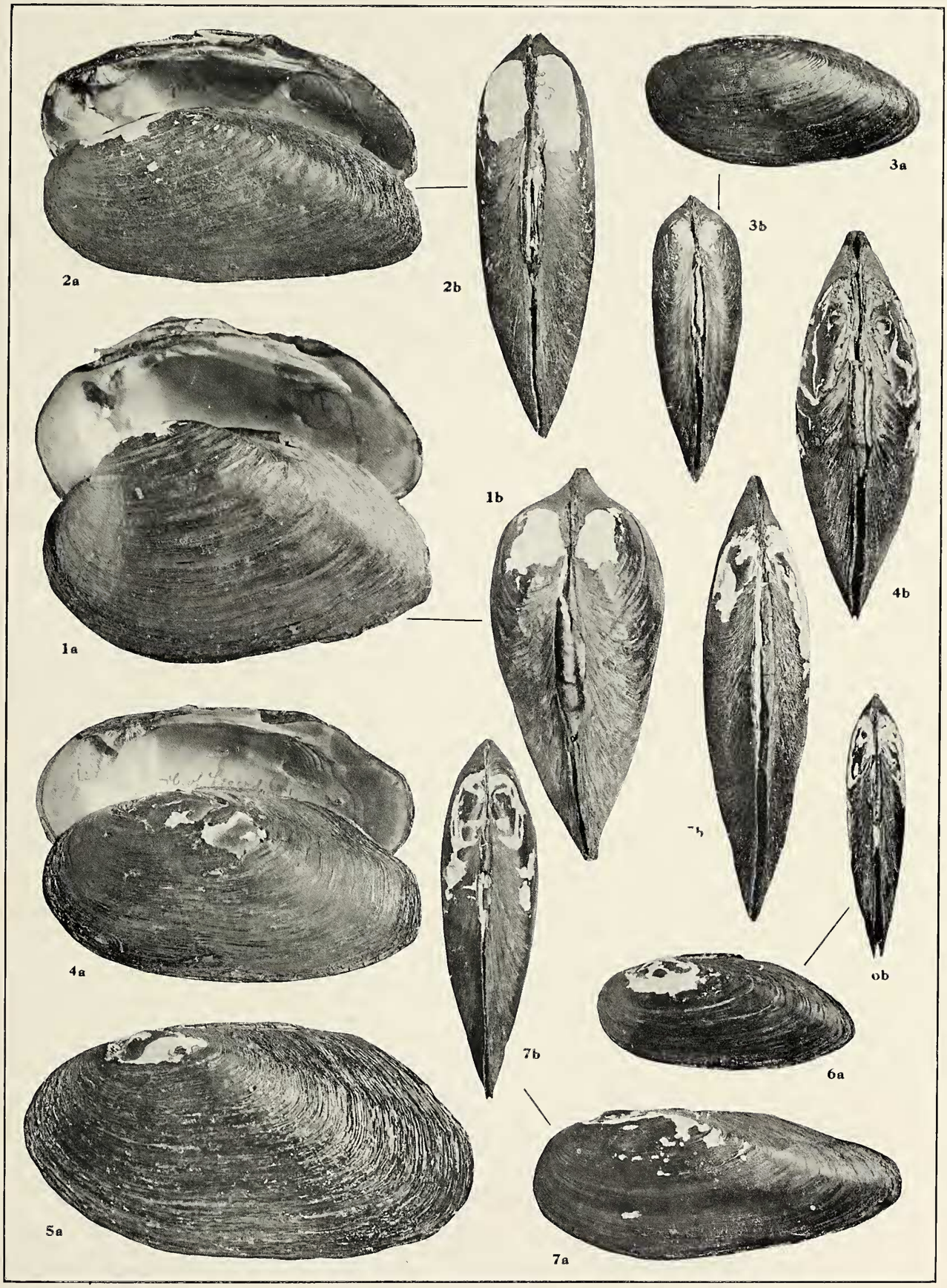
FIG. 3. *Elliptio dilatatus sterkii* Grier. Female, one of the types, which, however, is not much swollen, the diameter being only 32 percent of the length. From Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4628.

FIG. 4. *Elliptio violaceus* (Spengler). Normal specimen as found in smaller streams, from a small tributary of Lizard Creek, West Pēnn, Schuylkill Co., Pennsylvania, collected May 4, 1909; C. M. Cat. No. 61.4308.

FIG. 5. *Elliptio violaceus* (Spengler). Strongly compressed form with rough epidermis corresponding to the form called *jejunus* by Lea, from a mill-race of Crooked Creek, Tioga, Tioga Co., Pennsylvania, collected August 19, 1909; C. M. Cat. No. 61.4312.

FIG. 6. *Elliptio cupreus* (Rafinesque). Specimen of medium size from Great Tonoloway Creek, Thompson Township, Fulton Co., Pennsylvania, collected September 5, 1909; C. M. Cat. No. 61.4322.

FIG. 7. *Elliptio fisherianus* (Lea). Normal specimen of medium size from Choptank Mills, Kent Co., Delaware, collected by S. N. Rhoads, June, 1903; C. M. Cat. No. 61.4645.



Elliptio.

EXPLANATION OF PLATE IX.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lasmigona* (*Platynaias*) *viridis* (Rafinesque). Gravid specimen, about full-grown, from Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected May 14, 1908; C. M. Cat. No. 61.3297.

Fig. 2. *Lasmigona* (*Patynaias*) *viridis* (Rafinesque). Gravid specimen, young. This specimen shows the great similarity of young *L. viridis* to *L. subviridis* (compare Fig. 4). From Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected August 7, 1908; C. M. Cat. No. 61.3679.

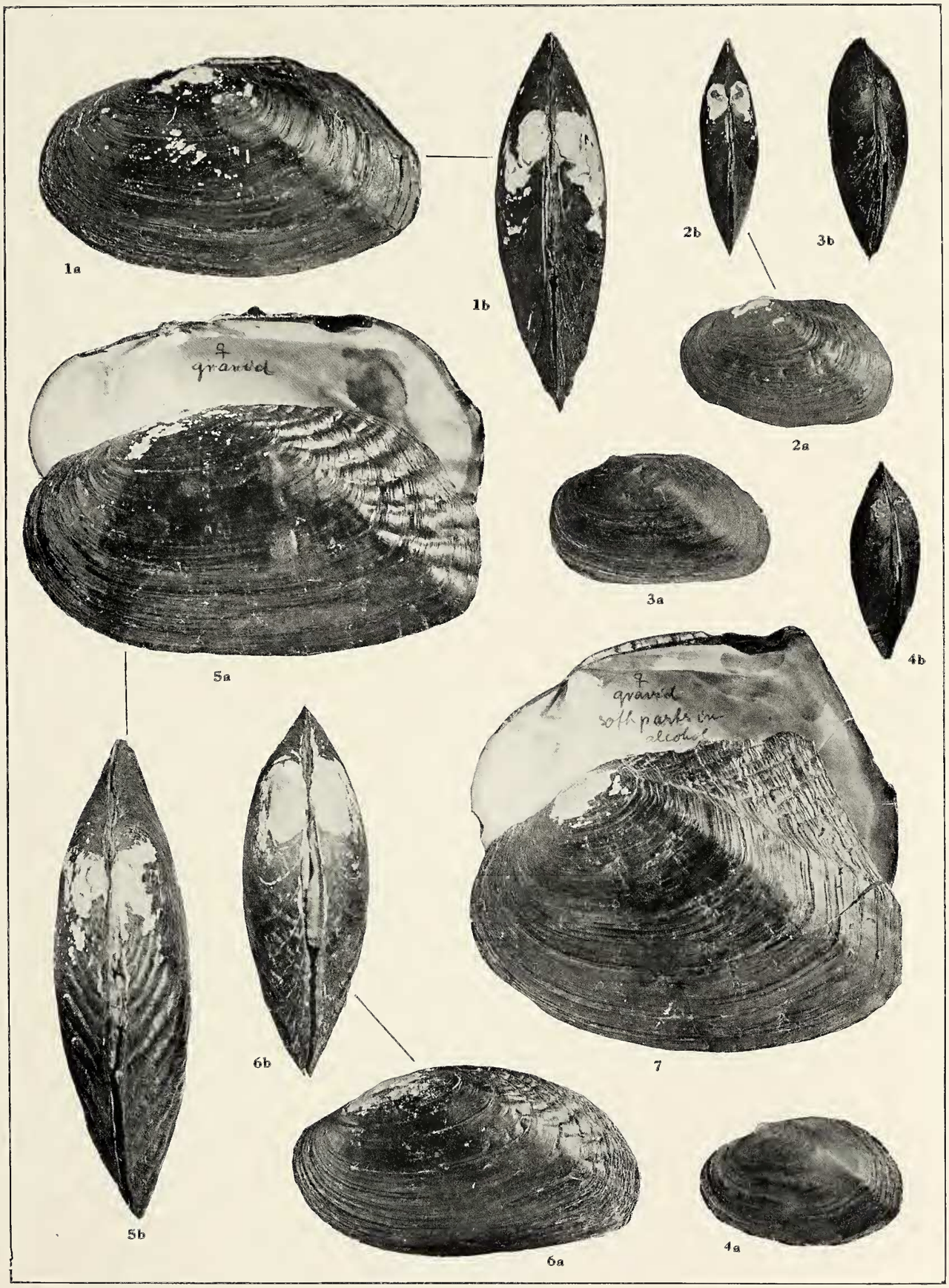
Fig. 3. *Lasmigona* (*Platynaias*) *subviridis* (Conrad). Gravid specimen, about full-grown, with exceptionally solid shell, from water heavily charged with lime. From Conococheague Creek, Greencastle, Franklin Co., Pennsylvania, collected September 6, 1909; C. M. Cat. No. 61.4222.

Fig. 4. *Lasmigona* (*Platynaias*) *subviridis* (Conrad). Gravid specimen of the normal, thin-shelled form, from Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania, collected April 24, 1909; C. M. Cat. No. 61.4219.

Fig. 5. *Lasmigona* (*Lasmigona*) *costata* (Rafinesque). Gravid female of typical shape, from Shenango River, Shenango, Mercer Co., Pennsylvania, collected September 27, 1909; C. M. Cat. No. 61.4235.

Fig. 6. *Lasmigona* (*Lasmigona*) *costata eriganensis* Grier. Specimen from the set of types. From Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 22, 1909; C. M. Cat. No. 61.4223.

Fig. 7. *Lasmigona* (*Pterosyna*) *complanata* (Barnes). Gravid female, not quite full-grown, from Leboeuf Creek, Waterford, Erie Co., Pennsylvania, collected September 14, 1909; C. M. Cat. No. 61.4238.


1a
1b
2b
3b
2a
3a
4b
5a
♀ gravid
5b
6b
6a
4a
7
♀ gravid soft parts in alcohol

Lasmigona.

EXPLANATION OF PLATE X.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

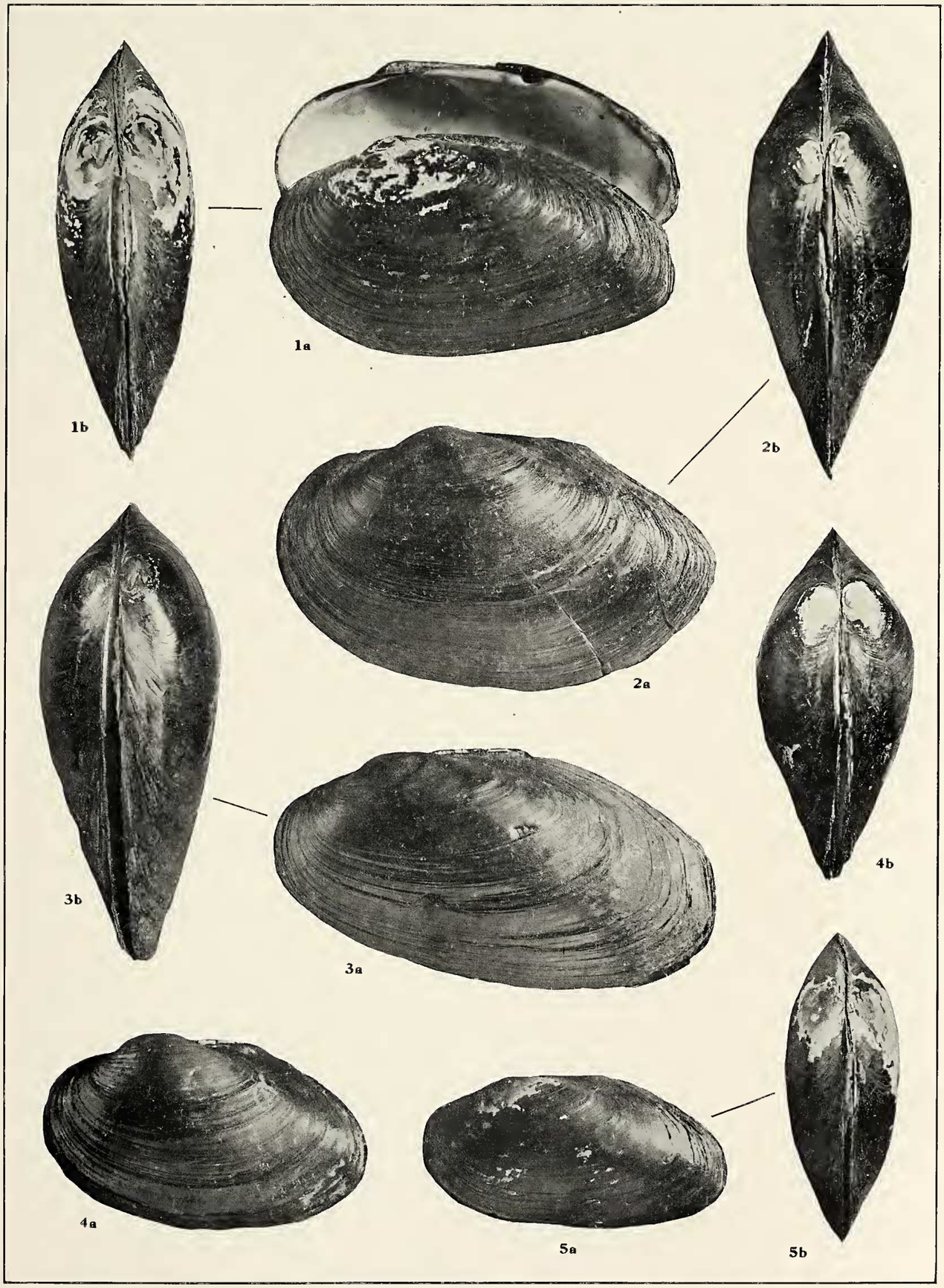
Fig. 1. *Anodonta grandis* Say. Normal creek-form, from Crooked Creek, Creekside, Indiana Co., Pennsylvania, collected May 27, 1908; C. M. Cat. No. 61.3649.

Fig. 2. *Anodonta grandis* Say. Gravid female of the pond-form *gigantea* (Lea), from pond at Harmarville, Allegheny Co., Pennsylvania, collected October 17, 1910; C. M. Cat. No. 61.4742.

Fig. 3. *Anodonta grandis footiana* (Lea). The form of the beach-pools, from Lake Erie, beach-pools of Presque Isle, Erie, Erie Co., Pennsylvania, collected June 2, 1908; C. M. Cat. No. 61.3651.

Fig. 4. *Anodonta grandis footiana* (Lea). Female of the form found in Presque Isle Bay, from Lake Erie, Presque Isle Bay (flats near west end), Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4733.

Fig. 5. *Anodonta cataracta* Say. Creek-form, about half-grown, from White Clay Creek, Avondale, Chester Co., Pennsylvania, collected April 26, 1909; C. M. Cat. No. 61.4167.



Anodonta.

EXPLANATION OF PLATE XI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Anodonta cataracta* Say. Gravid female of pond-form, of good size, from Pond near Paper Mill, Lockhaven, Clinton Co., Pennsylvania, collected August 24, 1909; C. M. Cat. No. 61.4173.

Fig. 2. *Anodonta implicata* Say. Normal specimen, rather swollen, from Timber Creek, Newbold, Gloucester Co., New Jersey, collected by C. H. Conner; C. M. Cat. No. 61.4442.

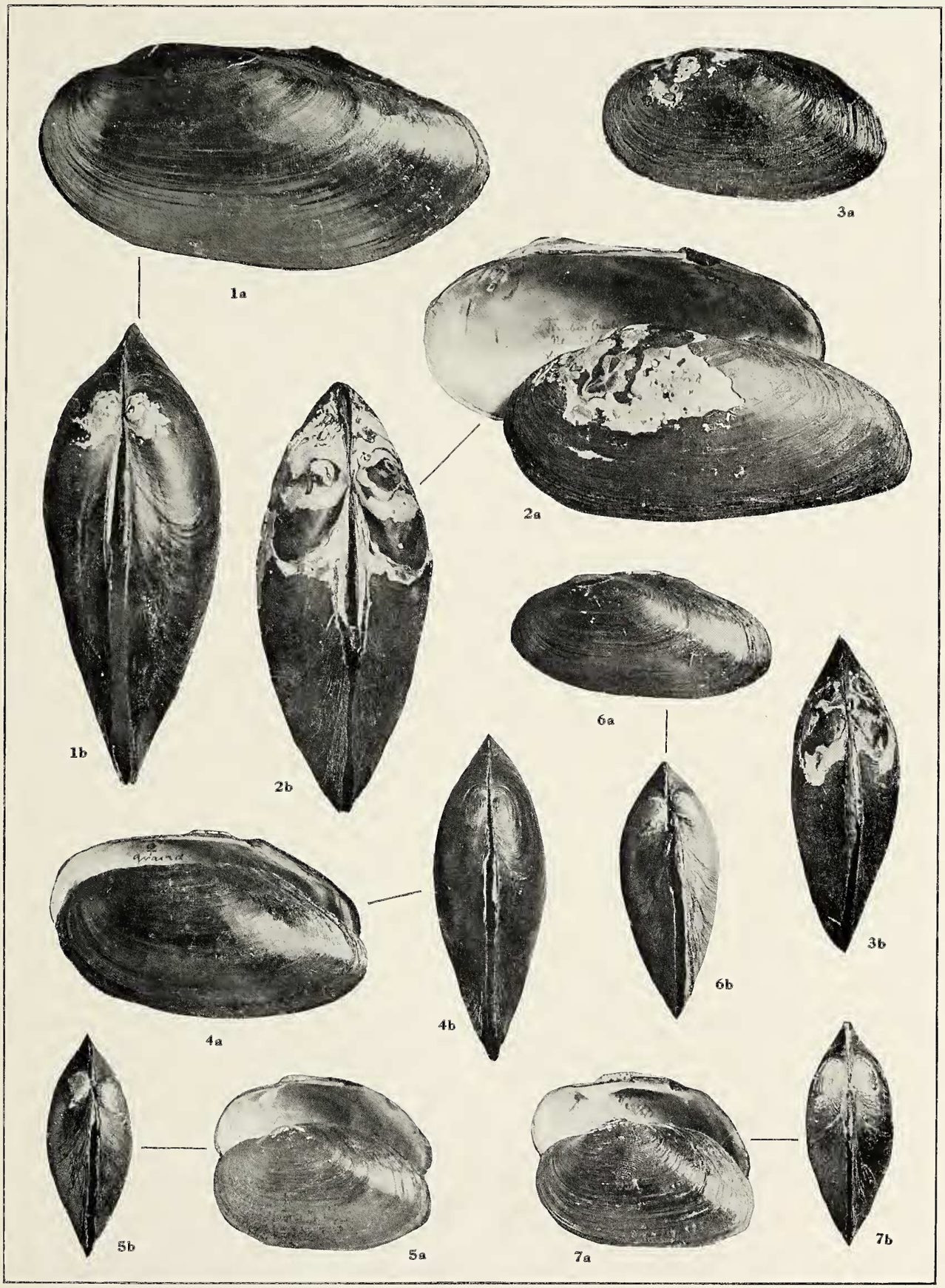
Fig. 3. *Anodonta implicata* Say. Young specimen of the river-form, from Delaware River, Yardley, Bucks Co., Pennsylvania, collected August 24, 1908; C. M. Cat. No. 61.3693.

Fig. 4. *Anodonta ohiënsis* Rafinesque. Gravid specimen, rather large, from Lake Erie, beach-pool of Presque Isle, Erie, Erie Co., Pennsylvania, collected June 2, 1908; C. M. Cat. No. 61.3291.

Fig. 5. *Anodontoides ferussacianus* (Lea). Specimen of medium size, from Little Shenango River, Greenville, Mercer Co., Pennsylvania, collected June 5, 1908; C. M. Cat. No. 61.3294.

Fig. 6. *Anodontoides ferussacianus buchanensis* (Lea). Typical specimen of medium size from Lake Erie, beach-pool of Presque Isle, Erie, Erie Co., Pennsylvania, collected June 2, 1908; C. M. Cat. No. 61.3295.

Fig. 7. *Alasmidonta* (*Alasmidonta*) *undulata* (Say). Gravid female of normal shape, from Conodoguinet Creek, Carlisle, Cumberland Co., Pennsylvania, collected August 13, 1910; C. M. Cat. No. 61.4660.



Anodonta-Anadontoides-Alasmidonta.

EXPLANATION OF PLATE XII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Alasmidonta* (*Prolasmidonta*) *heterodon* (Lea). Adult male from the Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania, collected April 24, 1909; C. M. Cat. No. 61.4250.

Fig. 2. *Alasmidonta* (*Prolasmidonta*) *heterodon* (Lea). Adult gravid female from the Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania, collected April 24, 1909; C. M. Cat. No. 61.4250.

Fig. 3. *Alasmidonta* (*Decurambis*) *marginata* (Say). Adult gravid female from the Shenango River, Shenango, Mercer Co., Pennsylvania, collected September 27, 1909; C. M. Cat. No. 61.4270.

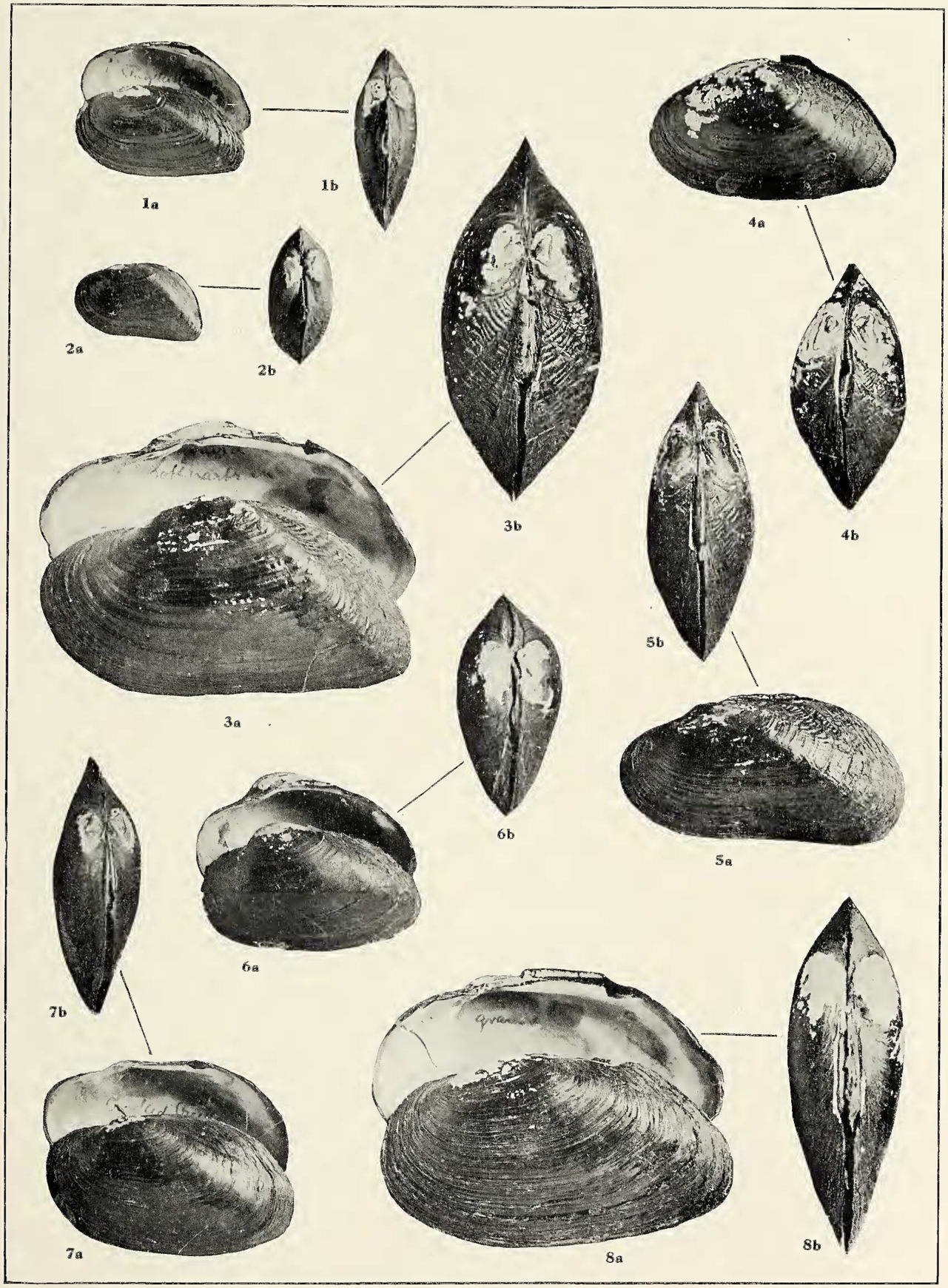
Fig. 4. *Alasmidonta* (*Decurambis*) *marginata susquehannæ* Ortmann. Male from the set of types, from the Susquehanna River, Selinsgrove, Snyder Co., Pennsylvania, collected August 14, 1910; C. M. Cat. No. 61.4679.

Fig. 5. *Alasmidonta* (*Decurambis*) *varicosa* (Lamarck). Adult female, from Princess Creek, Kunkletown, Monroe Co., Pennsylvania, collected June 14, 1910; C. M. Cat. No. 61.4671.

Fig. 6. *Strophitus undulatus* (Say). Specimen supposed to be this species, from Delaware River, Newbold, Gloucester Co., New Jersey, collected by C. H. Conner; C. M. Cat. No. 61.4135.

Fig. 7. *Strophitus edentulus* (Say). Half-grown male, from a mill-race of Crooked Creek, Tioga, Tioga Co., Pennsylvania, collected August 19, 1909; C. M. Cat. No. 61.4154.

Fig. 8. *Strophitus edentulus* (Say). Adult gravid female, from Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected August 7, 1908; C. M. Cat. No. 61.3613.



Alasmidonta-Strophitus.

EXPLANATION OF PLATE XIII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Ellipsaria fasciolaris* (Rafinesque). Gravid female from the Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected August 4, 1908; C. M. Cat. No. 61.3589.

FIG. 2. *Ellipsaria fasciolaris* (Rafinesque). Inside of female shell, showing the marsupial depressions, from the Shenango River, Pulaski, Lawrence Co., Pennsylvania, collected July 19, 1909; C. M. Cat. No. 61.4128.

FIG. 3. *Ellipsaria fasciolaris* (Rafinesque). Form of Lake Erie, female, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4748.

FIG. 4. *Obliquaria reflexa* Rafinesque. Male, largest found in Pennsylvania, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 5, 1909; C. M. Cat. No. 61.4423.

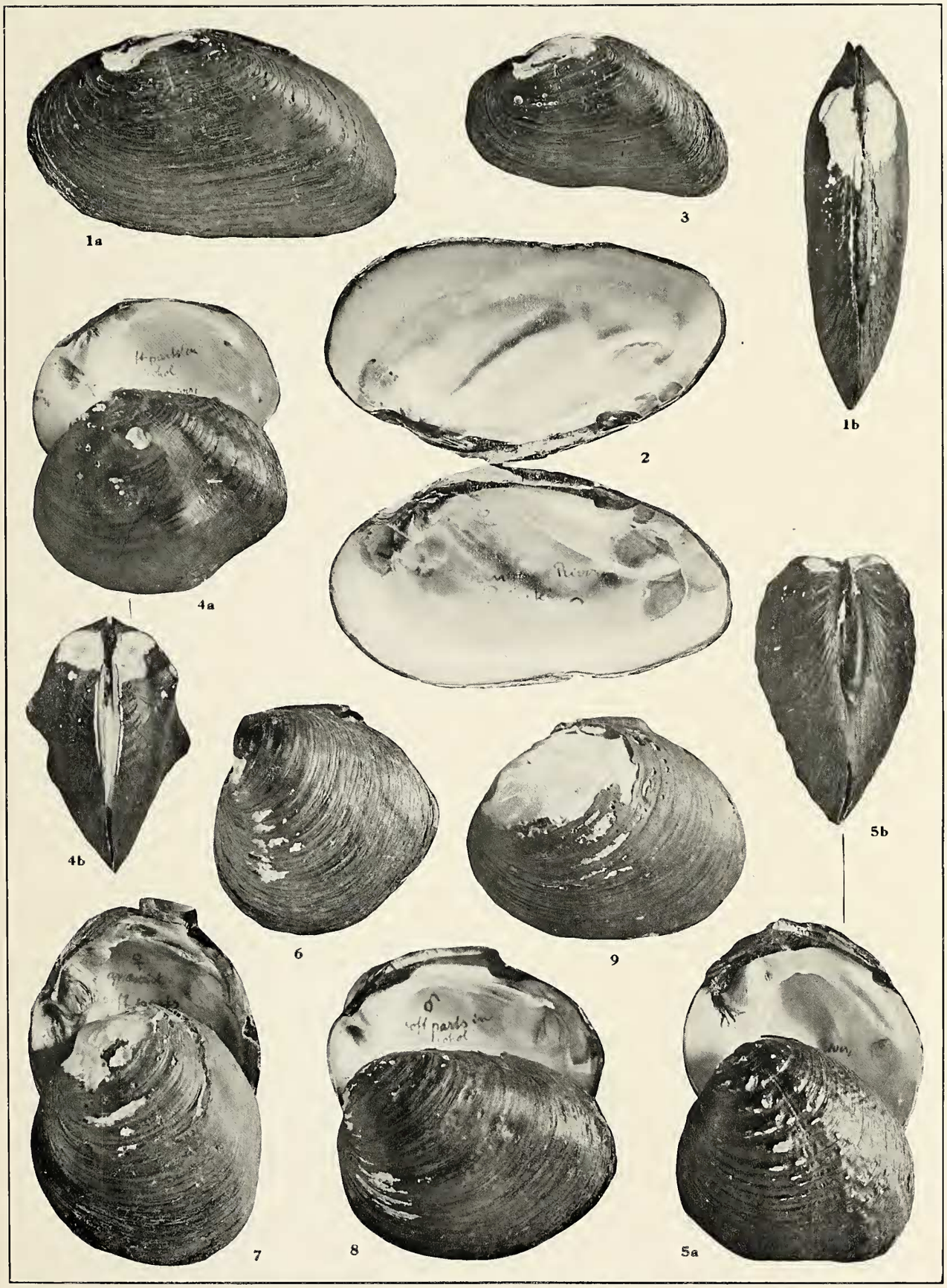
FIG. 5. *Cyprogenia stegaria* (Rafinesque). Largest specimen found in Pennsylvania in the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 27, 1910; C. M. Cat. No. 61.4760.

FIG. 6. *Obovaria* (*Obovaria*) *retusa* (Lamarck). The only male (dead shell) found in Pennsylvania in the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 22, 1908; C. M. Cat. No. 61.3556.

FIG. 7. *Obovaria* (*Obovaria*) *retusa* (Lamarck). Gravid female, the only living specimen found in Pennsylvania, in the Ohio River, Industry, Beaver Co., Pennsylvania, collected August 29, 1908; C. M. Cat. No. 61.3555.

FIG. 8. *Obovaria* (*Pseudoön*) *olivaria* (Rafinesque). Male from the Ohio River, Portland, Meigs Co., Ohio, collected September 22, 1910; C. M. Cat. No. 61.4776.

FIG. 9. *Obovaria* (*Pseudoön*) *olivaria* (Rafinesque). Female from the Ohio River, Industry, Beaver Co., Pennsylvania, collected August 29, 1908; C. M. Cat. No. 61.3561.



Ellipsaria-Obliquaria-Cyprogenia-Obovaria.

EXPLANATION OF PLATE XIV.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Obovaria* (*Obovaria*) *subrotunda* (Rafinesque). Probably male according to shape, diameter 68 percent of length, from the Monongahela River, Charleroi, Washington Co., Pennsylvania, collected by G. A. Ehrmann; C. M. Cat. No. 61.2840.

FIG. 2. *Obovaria* (*Obovaria*) *subrotunda* (Rafinesque). Probably a female, judging from the shape; diameter 62 percent of length, from the Monongahela River, Charleroi, Washington Co., Pennsylvania, collected by G. A. Ehrmann; C. M. Cat. No. 61.2840.

FIG. 3. *Obovaria* (*Obovaria*) *subrotunda levigata* (Rafinesque). Male, diameter 50 percent of length, from the Shenango River, Clarksville, Mercer Co., Pennsylvania collected September 21, 1908; C. M. Cat. No. 61.3558.

FIG. 4. *Obovaria* (*Obovaria*) *subrotunda levigata* (Rafinesque). Female, diameter 52 percent of length, from the Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3558.

FIG. 5. *Actinonaias ligamentina* (Lamarck). Male of medium size from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected October 4, 1907; C. M. Cat. No. 61.3108.

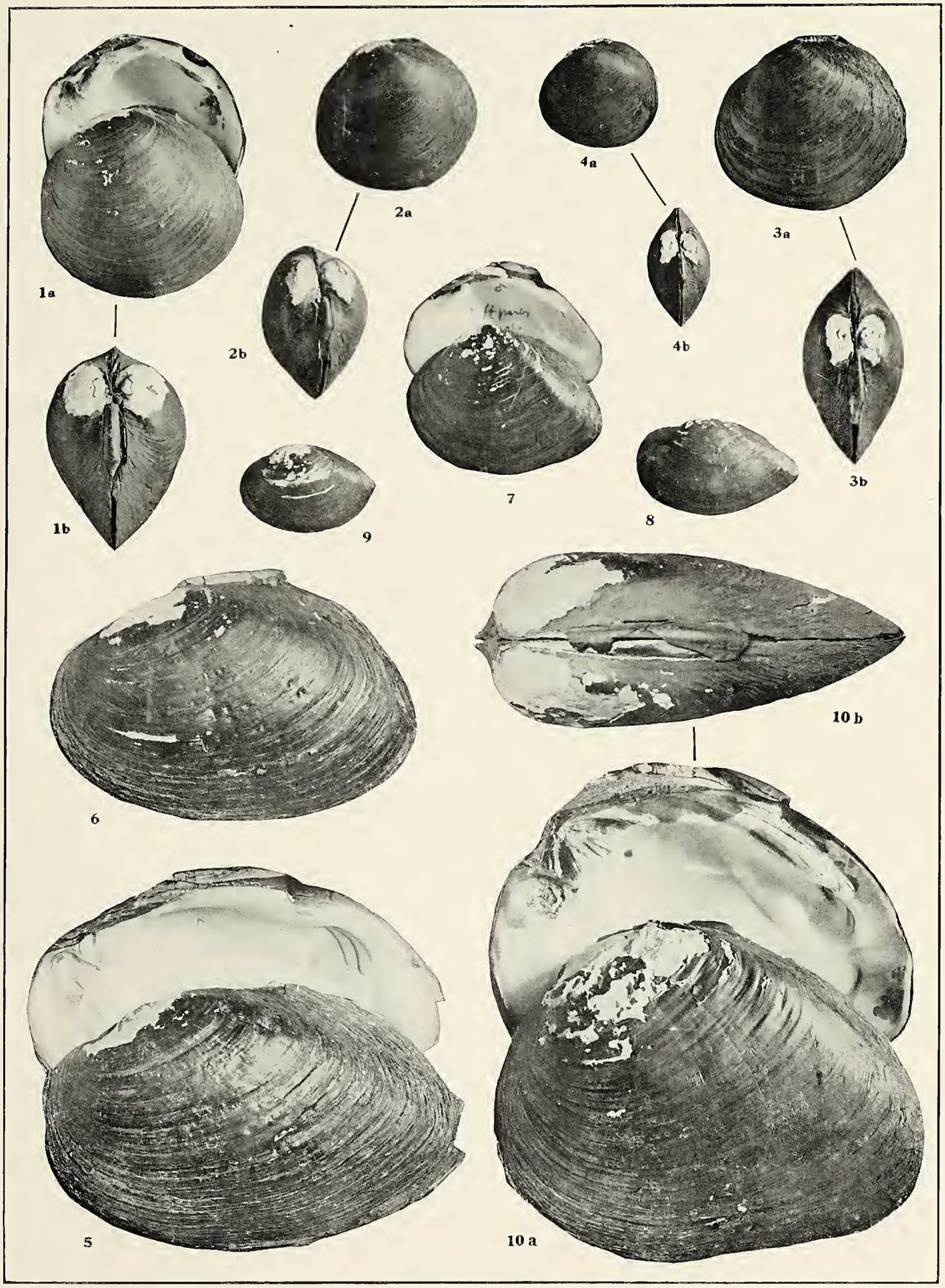
FIG. 6. *Actinonaias ligamentina* (Lamarck). Gravid female of medium size from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected October 4, 1907; C. M. Cat. No. 61.3108.

FIG. 7. *Amygdalonaias truncata* (Rafinesque). Male from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 8, 1908; C. M. Cat. No. 61.3569.

FIG. 8. *Amygdalonaias donaciformis* (Lea). Male from the Missouri River, St. Joseph, Buchanan Co., Missouri, collected by W. I. Utterback, November 1, 1913; C. M. Cat. No. 61.6887.

FIG. 9. *Amygdalonaias donaciformis* (Lea). Female from the Missouri River, St. Joseph, Buchanan Co., Missouri, collected by W. I. Utterback, November 1, 1913; C. M. Cat. No. 61.6887.

FIG. 10. *Plagiola lineolata* (Rafinesque). Adult male from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 12, 1908; C. M. Cat. No. 61.3565.



Obovaria-Actinonaias-Amygdalonaias-Plagiola.

EXPLANATION OF PLATE XV.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Plagiola lineolata* (Rafinesque). Half-grown male from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 10, 1908; C. M. Cat. No. 61.3565.

FIG. 2. *Plagiola lineolata* (Rafinesque). Adult gravid female from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 12, 1908; C. M. Cat. No. 61.3565.

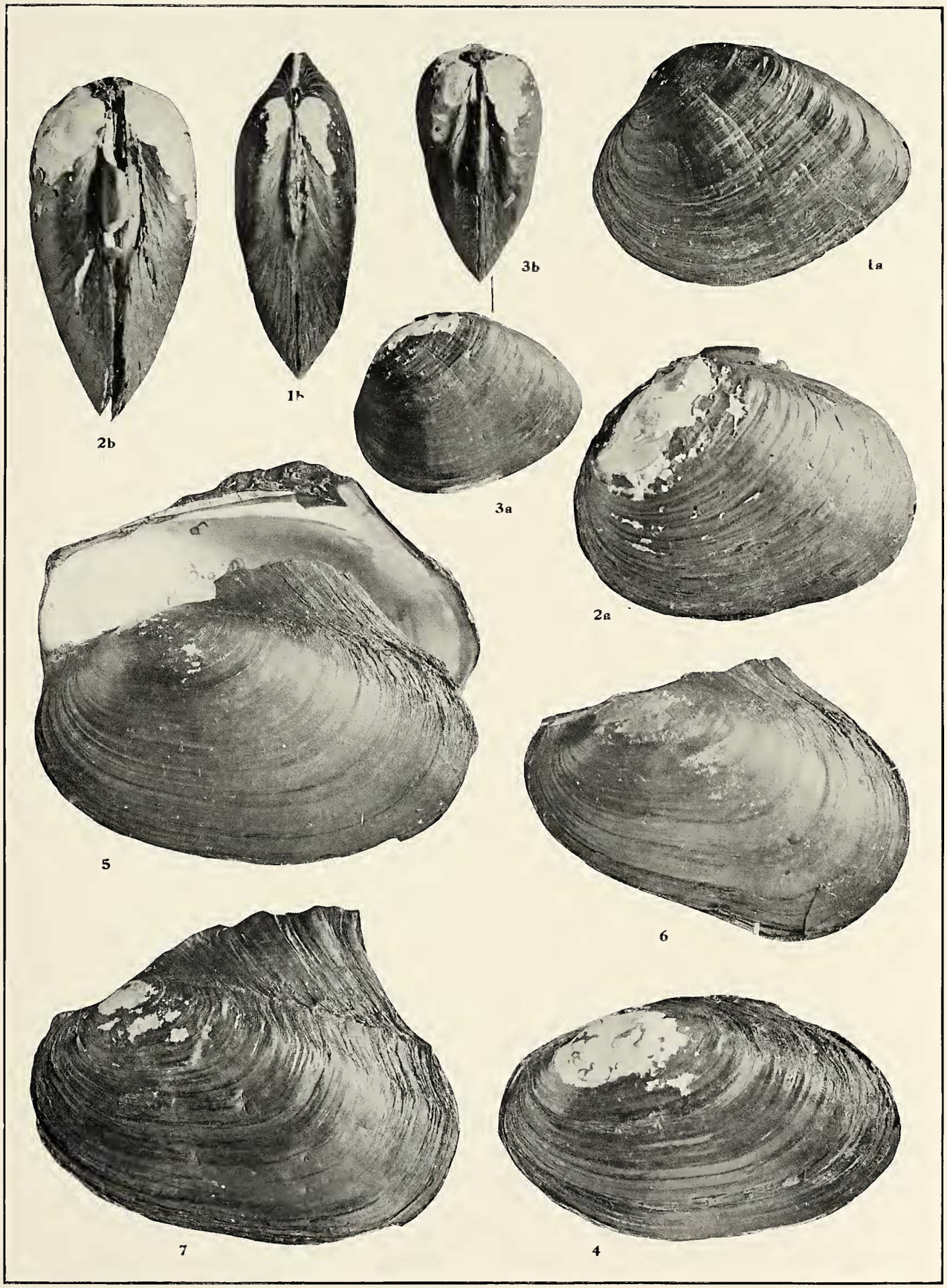
FIG. 3. *Plagiola lineolata* (Rafinesque). Half-grown gravid female from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 10, 1908; C. M. Cat. No. 61.3565.

FIG. 4. *Paraptera fragilis* (Rafinesque). Male of Ohio-form from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 23, 1908; C. M. Cat. No. 61.3549.

FIG. 5. *Paraptera fragilis* (Rafinesque). Male of Lake Erie-form from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4807.

FIG. 6. *Paraptera fragilis* (Rafinesque). Female of Lake Erie-form from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4807.

FIG. 7. *Proptera alata* (Say). Male of Ohio-form, about half-grown, from Ohio River, Industry, Beaver Co., Pennsylvania, collected August 30, 1909; C. M. Cat. No. 61.4108.



Plagiola-Paraptera-Proptera.

EXPLANATION OF PLATE XVI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Proptera alata* (Say). Gravid female of Ohio-form, half-grown, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected August 30, 1909; C. M. Cat. No. 61.4108.

Fig. 2. *Proptera alata* (Say). Gravid female of Lake Erie-form, nearly adult, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 21, 1909; C. M. Cat. No. 61.4102.

Fig. 3. *Toxolasma parvum* (Barnes). Gravid female from Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected June 17, 1909; C. M. Cat. No. 61.4101.

Fig. 4. *Eurynia* (*Micromya*) *fabalis* (Lea). Male, according to shape, from Allegheny River, Walnut Bend, Venango Co., Pennsylvania, collected September 6, 1908; C. M. Cat. No. 61.3376.

Fig. 5. *Eurynia* (*Micromya*) *fabalis* (Lea). Female, judging from the shape, from the Allegheny River, Walnut Bend, Venango Co., Pennsylvania, collected September 6, 1908; C. M. Cat. No. 61.3376.

Fig. 6. *Eurynia* (*Micromya*) *iris* (Lea). Male from Slipperyrock Creek, Wurtemberg, Lawrence Co., Pennsylvania, collected June 23, 1910; C. M. Cat. No. 61.4827.

Fig. 7. *Eurynia* (*Micromya*) *iris* (Lea). Gravid female from Little Beaver Creek, Enon Valley, Lawrence Co., Pennsylvania, collected May 11, 1907; C. M. Cat. No. 61.2159.

Fig. 8. *Eurynia* (*Micromya*) *iris novi-eboraci* (Lea). Male from Conneaut Creek, West Springfield, Erie Co., Pennsylvania, collected May 23, 1909; C. M. Cat. No. 61.4091.

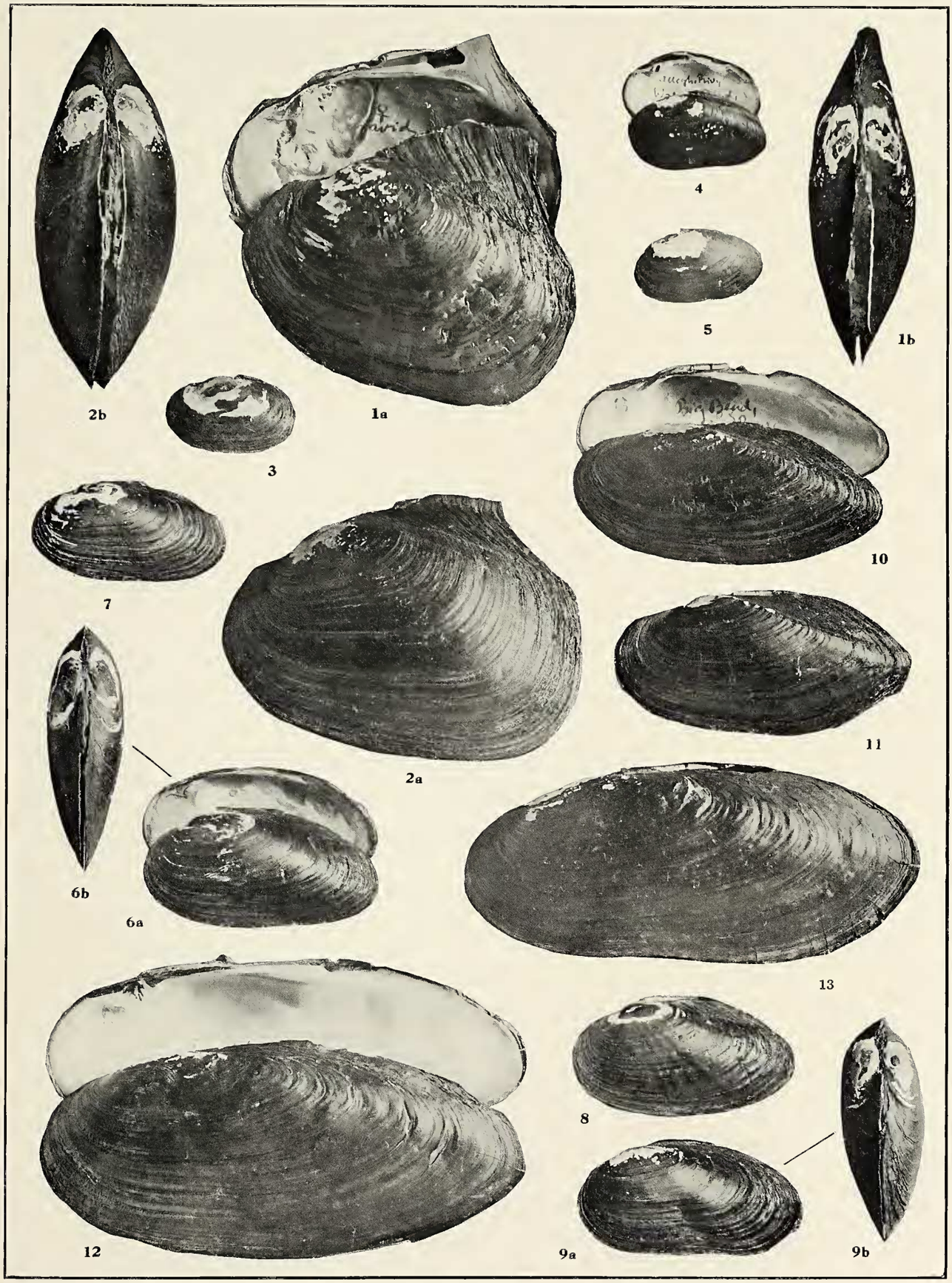
Fig. 9. *Eurynia* (*Micromya*) *iris novi-eboraci* (Lea). Female, judging from the shape, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 7, 1910; C. M. Cat. No. 61.4831.

Fig. 10. *Eurynia* (*Eurynia*) *nasuta* (Say). Male from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4840.

Fig. 11. *Eurynia* (*Eurynia*) *nasuta* (Say). Female from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4840.

Fig. 12. *Eurynia* (*Eurynia*) *recta* (Lamarck). Male of medium size from French Creek, Meadville, Crawford Co., Pennsylvania, collected September 1, 1908; C. M. Cat. No. 61.3512.

Fig. 13. *Eurynia* (*Eurynia*) *recta* (Lamarck). Gravid female of medium size from French Creek, Meadville, Crawford Co., Pennsylvania, collected September 1, 1908; C. M. Cat. No. 61.3512.



Proptera-Toxolasma-Eurynia.

EXPLANATION OF PLATE XVII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lampsilis luteola* (Lamarck). Male from Mahoning River, Edinburg, Lawrence Co., Pennsylvania, collected September 15, 1908; C. M. Cat. No. 61.3466.

Fig. 2. *Lampsilis luteola* (Lamarck). Gravid female from Mahoning River, Edinburg, Lawrence Co., Pennsylvania, collected September 15, 1908; C. M. Cat. No. 61.3466.

Fig. 3. *Lampsilis luteola rosacea* (DeKay). Male, deep water form, with very regular growth-rests, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, taken at a depth of fourteen to sixteen feet, collected July 22, 1909; C. M. Cat. No. 61.4033.

Fig. 4. *Lampsilis luteola rosacea* (DeKay). Male, form of the open shore, from Lake Erie, outer shore of Presque Isle, Erie, Erie Co., Pennsylvania, from a depth of ten feet, collected July 11, 1910; C. M. Cat. No. 61.4862.

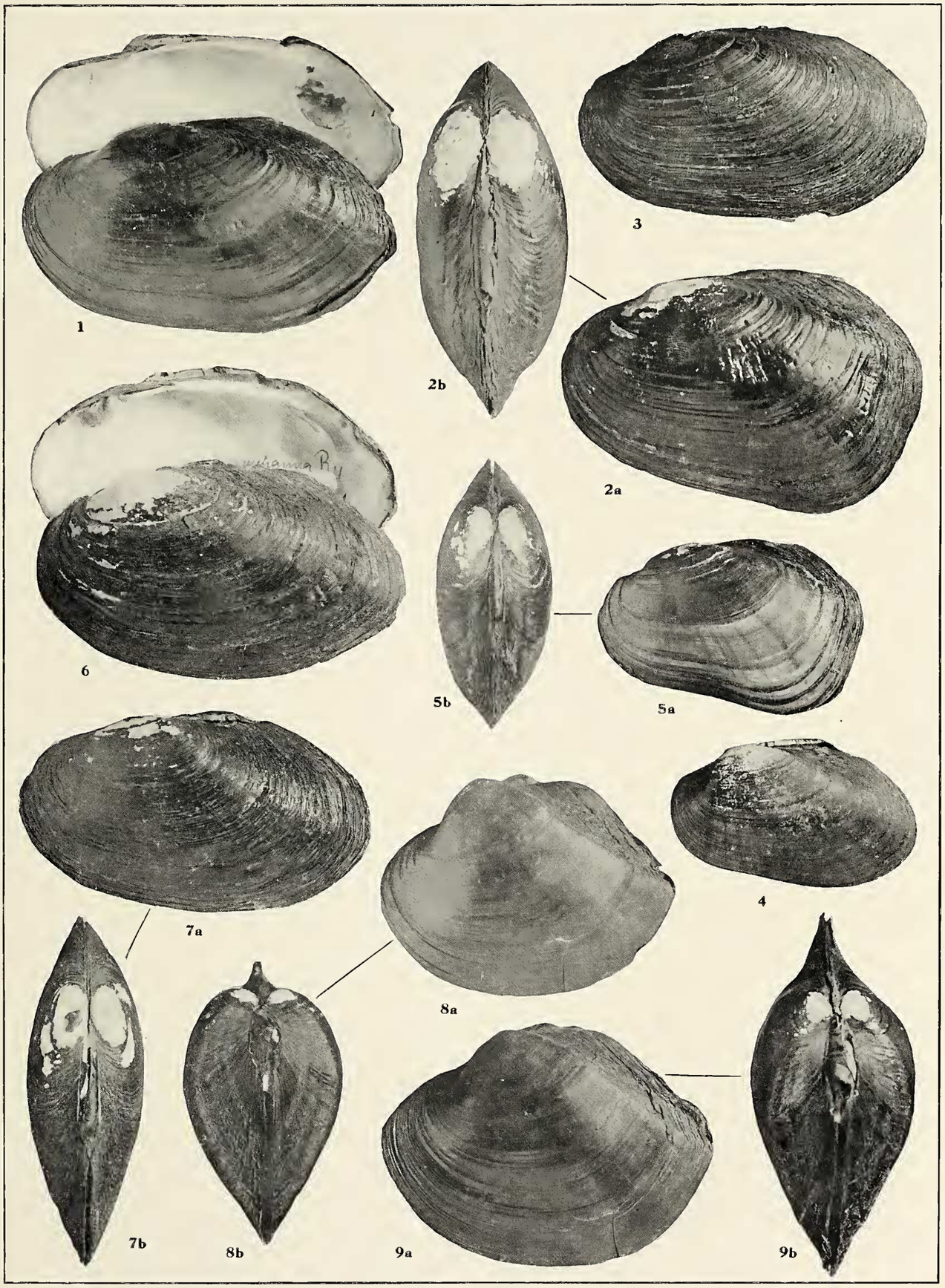
Fig. 5. *Lampsilis luteola rosacea* (DeKay). Female, normal form of the bay, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, taken from shallow water, collected July 9, 1910; C. M. Cat. No. 61.4861.

Fig. 6. *Lampsilis radiata* (Gmelin). Male from North Branch Susquehanna River, Tunkhannock, Wyoming Co., Pennsylvania, collected August 21, 1909; C. M. Cat. No. 61.4054.

Fig. 7. *Lampsilis radiata* (Gmelin). Gravid female from North Branch of the Susquehanna River, Tunkhannock, Wyoming Co., Pennsylvania, collected August 21, 1909; C. M. Cat. No. 61.4054.

Fig. 8. *Lampsilis ovata* (Say). Young specimen, probably male, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4010.

Fig. 9. *Lampsilis ovata* (Say). Young specimen, probably female, but female shape barely indicated, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4010.



Lampsilis.

EXPLANATION OF PLATE XVIII.

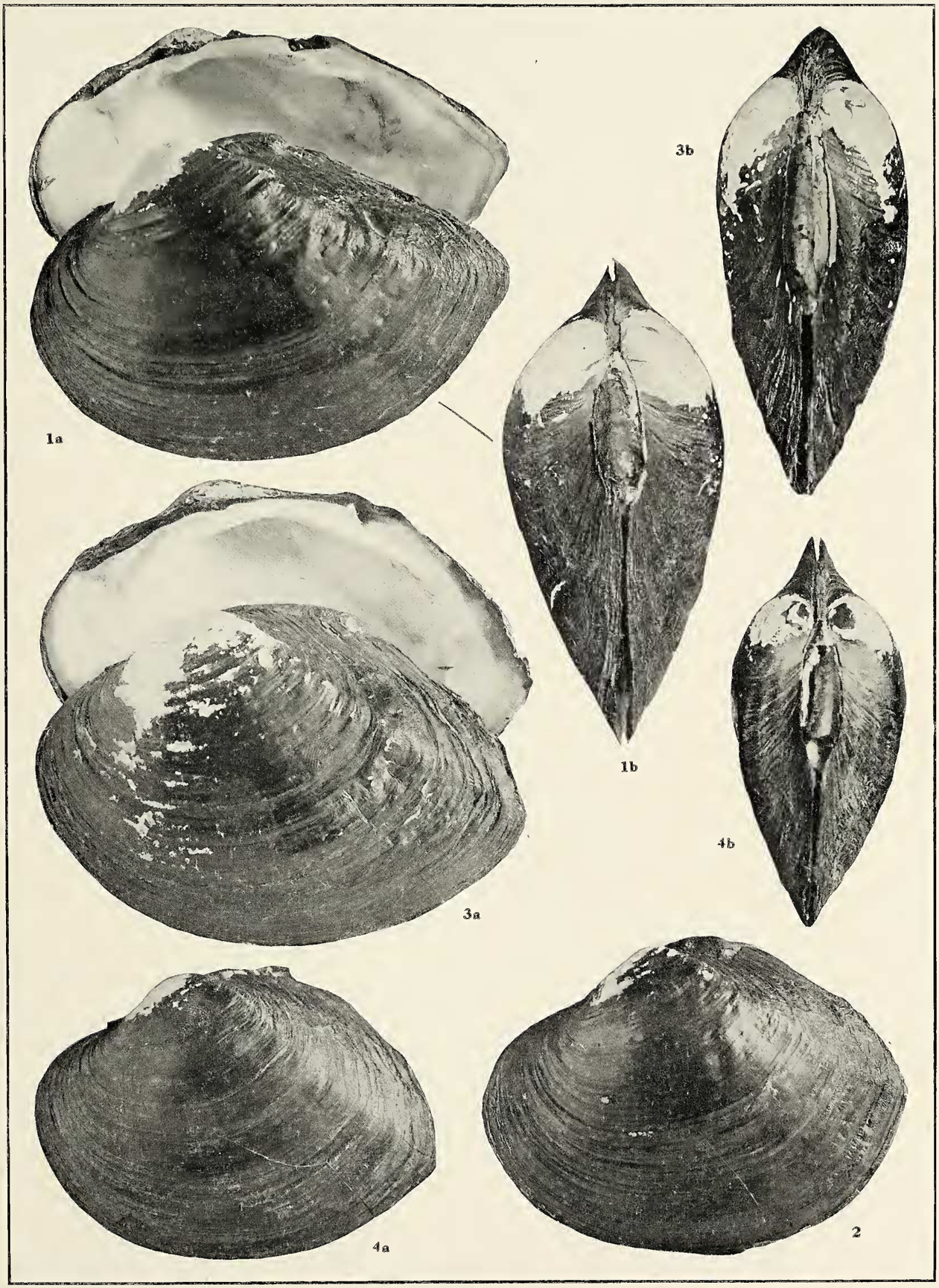
All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Lampsilis ovata* (Say). Normal adult male from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 30, 1907; C. M. Cat. No. 61.2994.

FIG. 2. *Lampsilis ovata* (Say). Normal gravid female from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 30, 1907; C. M. Cat. No. 61.2994.

FIG. 3. *Lampsilis ovata* (Say). Male, strongly inclining in shape toward the var. *ventricosa*, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected July 5, 1909; C. M. Cat. No. 61.4007.

FIG. 4. *Lampsilis ovata ventricosa* (Barnes). Male, slightly inclining toward the normal *ovata*, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.3996.



Lampsilis.

EXPLANATION OF PLATE XIX.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

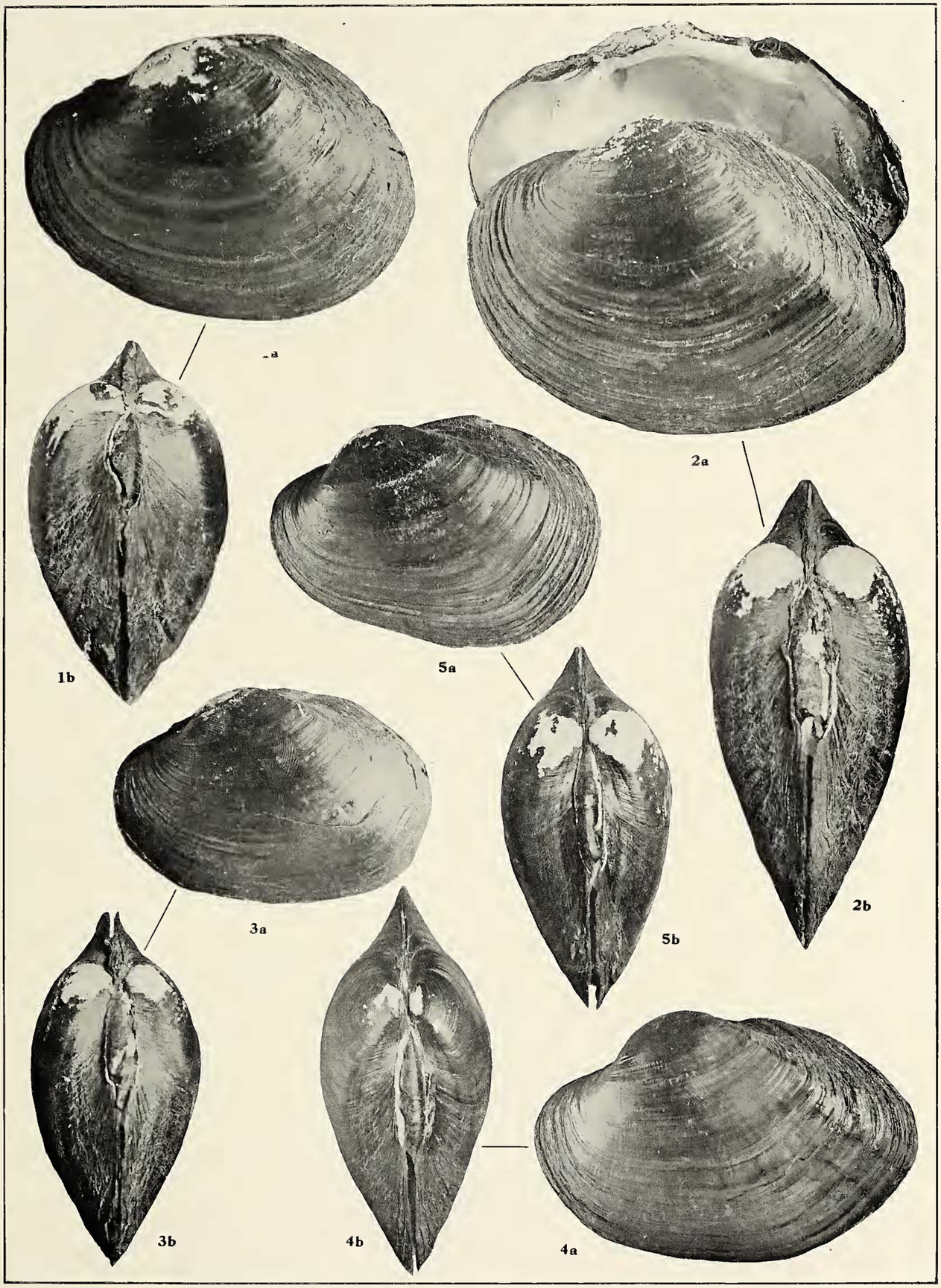
Fig. 1. *Lampsilis ovata ventricosa* (Barnes). Quite normal gravid female from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.3996.

Fig. 2. *Lampsilis ovata ventricosa* (Barnes). Typical male from the Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3404.

Fig. 3. *Lampsilis ovata ventricosa* (Barnes). Typical half-grown gravid female from the Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3404.

Fig. 4. *Lampsilis ovata canadensis* (Lea). Male from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 21, 1909; C. M. Cat. No. 61.3982.

Fig. 5. *Lampsilis ovata canadensis* (Lea). Female from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 22, 1909; C. M. Cat. No. 61.3982.



Lampsilis.

EXPLANATION OF PLATE XX.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lampsilis fasciola* Rafinesque. Male from Shenango River, Shenango, Mercer Co., Pennsylvania, collected September 27, 1909; C. M. Cat. No. 61.4099.

Fig. 2. *Lampsilis fasciola* Rafinesque. Gravid female from the Allegheny River, Warren, Warren Co., Pennsylvania, collected September 15, 1909; C. M. Cat. No. 61.4019.

Fig. 3. *Lampsilis cariosa* (Say). Very large male from the Chemung River, South Waverly, Bradford Co., Pennsylvania, collected August 20, 1909; C. M. Cat. No. 61.4003.

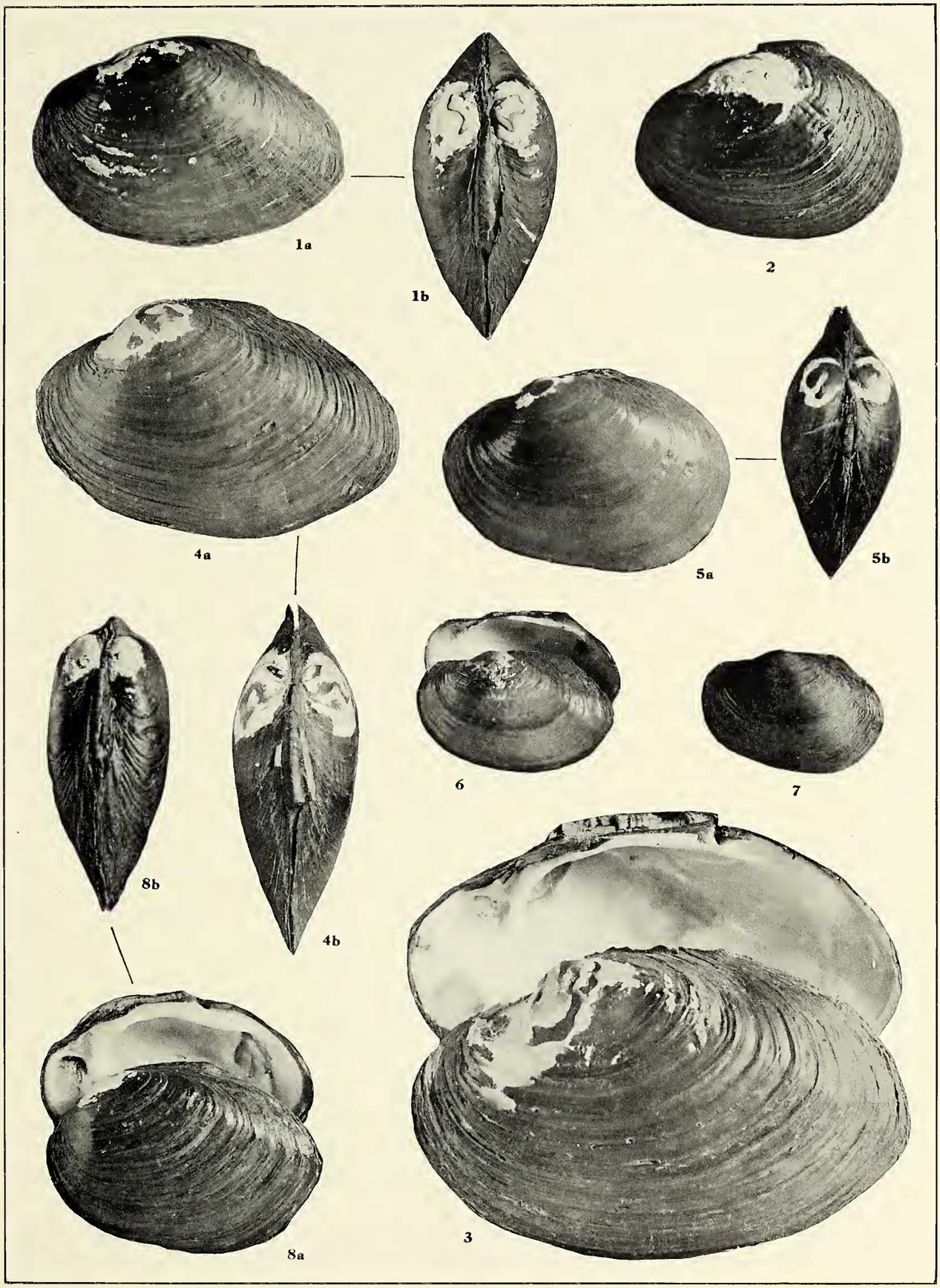
Fig. 4. *Lampsilis cariosa* (Say). Male of normal size from the Susquehanna River, Duncannon, Perry Co., Pennsylvania, collected August 14, 1908; C. M. Cat. No. 61.3414.

Fig. 5. *Lampsilis cariosa* (Say). Gravid female from the Susquehanna River, Duncannon, Perry Co., Pennsylvania, collected August 14, 1908; C. M. Cat. No. 61.3414.

Fig. 6. *Lampsilis ochracea* (Say). Probably male, judging from the shape, hardly half-grown, from an unknown locality in the Hartman collection; C. M. Cat. No. 61.4437.

Fig. 7. *Lampsilis ochracea* (Lea). Probably a female, judging from the shape, hardly half-grown, from the Delaware River, Newbold, Gloucester Co., New Jersey, collected by C. H. Conner; C. M. Cat. No. 61.4012.

Fig. 8. *Lampsilis orbiculata* (Hildreth). Half-grown male from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected October 8, 1908; C. M. Cat. No. 61.3504.



Lampsilis.

EXPLANATION OF PLATE XXI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lampsilis orbiculata* (Hildreth). Half-grown female from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected October 8, 1908; C. M. Cat. No. 61.3504.

Fig. 2. *Lampsilis orbiculata* (Hildreth). Very large and much swollen gravid female from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 23, 1908; C. M. Cat. No. 61.3500.

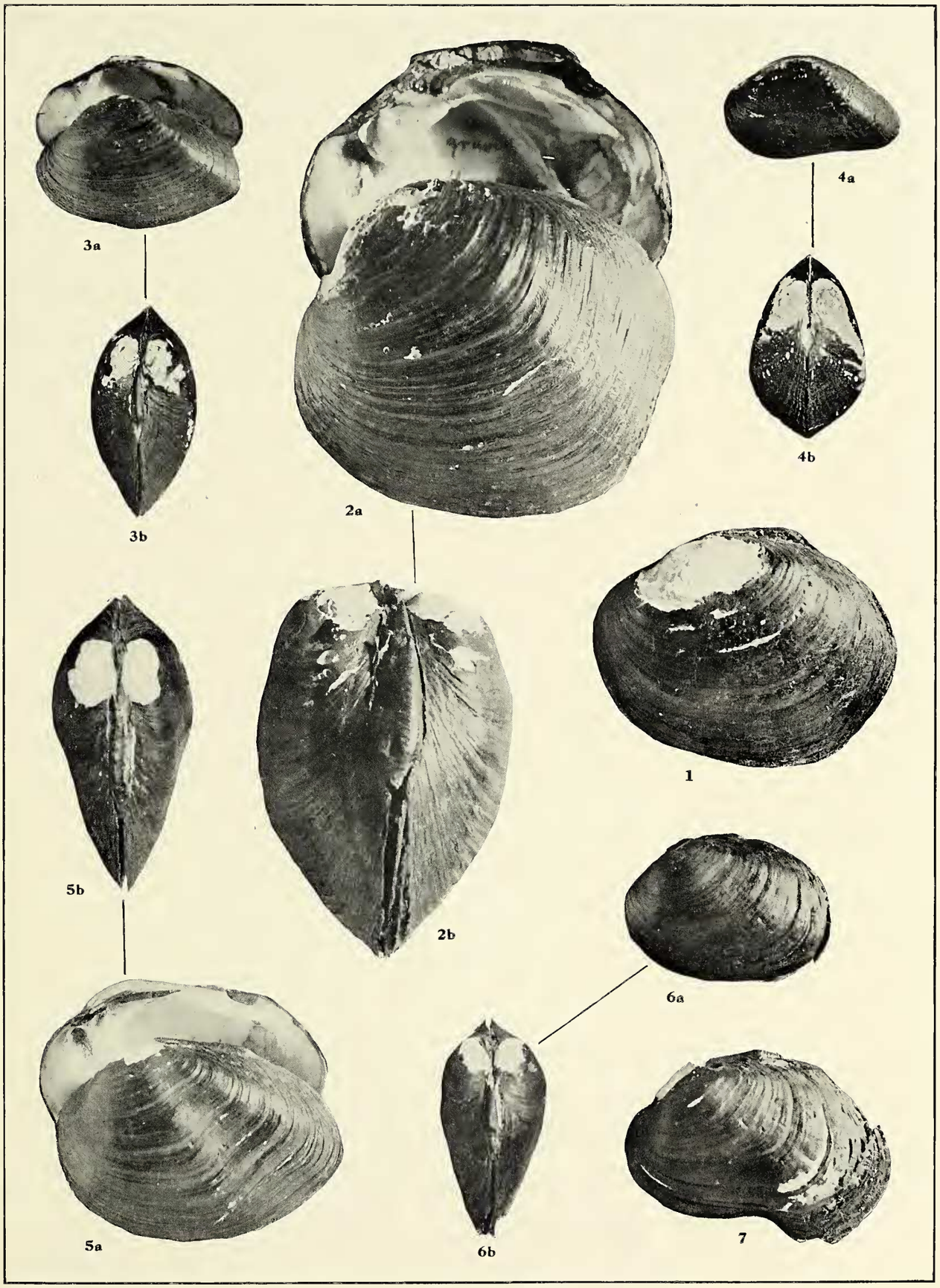
Fig. 3. *Truncilla triquetra* Rafinesque. Male from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.2985.

Fig. 4. *Truncilla triquetra* Rafinesque. Gravid female from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.2985.

Fig. 5. *Truncilla rangiana* (Lea). Adult male from French Creek, Cochranton, Crawford Co., Pennsylvania collected September 2, 1908; C. M. Cat. No. 61.3363.

Fig. 6. *Truncilla rangiana* (Lea). Half-grown female from French Creek, Cochranton, Crawford Co., Pennsylvania, collected September 2, 1908; C. M. Cat. No. 61.3363.

Fig. 7. *Truncilla rangiana* (Lea). Fully adult gravid female from French Creek, Cochranton, Crawford Co., Pennsylvania, collected September 2, 1908; C. M. Cat. No. 61.3363.



Lampsilis-Truncilla.